

Management and Conservation of VEGETATION IN AFRICA



BULLETIN NO. 41

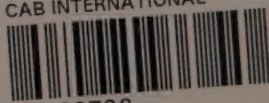
Commonwealth Bureau of
Pastures and Field Crops
Penglais, Aberystwyth, Wales

COMMONWEALTH AGRICULTURAL BUREAUX
FARNHAM ROYAL BUCKS ENGLAND

THIS symposium by scientists working in the British Commonwealth countries of Africa emphasizes the fact that, if periodic food shortages are to be avoided, soil conservation through the proper management of the vegetation cover is a major necessity. Shifting cultivation and the misuse of fire are becoming more alarming as the human population increases, so that the introduction of improved agricultural practices is an imperative need if the well-being of the peoples of Africa is to be safeguarded. The treatment of the subject is more from the standpoint of vegetation surveys and the mapping and description of the different broad types of vegetal cover, rather than land management. This approach illustrates the need in Africa for intensive vegetation surveys using a common technique and terminology.

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**MANAGEMENT AND CONSERVATION OF
VEGETATION IN AFRICA**

A Symposium



BULLETIN No. 41

OF THE

COMMONWEALTH BUREAU OF PASTURES AND FIELD CROPS

PENGLAIS, ABERYSTWYTH, WALES

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VEGETATION OF AFRICA

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STENNIS, ABERYSTWYTH, WALES

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FOREWORD

THIS Bulletin was originally intended to be one of a series planned by the writer and the former Director of the Commonwealth Forestry Bureau, Mr. J. W. B. Sisam. The series was intended to deal successively with different continents, and was expected to indicate how much the conservation of the soil depended on the proper management and conservation of the vegetation. For various reasons, only the Bulletin on Africa has been completed, and even this has not kept strictly to the original plan. The emphasis has come, quite naturally, to be placed on the survey, mapping and description of the different vegetation types, rather than on the optimal management of those types in the interests of conservation.

The great need in the African territories is for vegetation surveys on the basis of which maps can be prepared and plant associations analysed and described. Arising out of this, it is obviously desirable that surveyors in different territories should agree to use a common technique and terminology for the different associations which frequently extend from one territory into another, and may receive different names in the two areas.

The destruction or debasement of the vegetative cover of Africa has been going on for centuries; at the Conference held at Goma in the Belgian Congo in 1948, Monsieur Aubréville stated that the destruction of the African forests began when man first discovered fire. Fortunately interest in the whole problem of conservation of vegetation is increasing. At the Empire Scientific Conference in London in 1946, Dr. A. R. Saunders stated: "One of the main pillars of conservation research is the study of pasture management, of which the basic aim is the conservation of vegetation, soil and water supply. . . . It would appear as if the immediate object at least should . . . be co-ordination on a regional basis and an extensive scale." The appropriate section of the African Regional Scientific Conference held in Johannesburg in October, 1949, stressed "the urgent necessity for intensifying botanical research in taxonomy, ecology and plant geography, in order that fundamental information essential to research workers in applied science, now often inadequate or lacking, should become available for the economic development of the continent" (Dr. H. B. S. Cooke, in *Nature* of November 26th, 1949).

It is hoped that some of the fundamental information provided by the specialists contributing to this Bulletin will begin to meet this need.

R. O. WHYTE.

I. CONSERVATION OF VEGETATION IN SOUTH AFRICA

BY

J. D. SCOTT

ONLY three centuries ago the first colonists arrived in South Africa to produce the requirements of ships of the Dutch East India Company, calling in at Table Bay on their way to and from India. The first settlement was in and around what is now known as the Cape Peninsula. Soon the settlers began moving away and, by 1730, colonists had pushed north as far as Piquetberg and east along the coast as far as George, all within areas of winter rainfall.

During the next 70 years they had reached far into the areas of summer rainfall, both Karoo and grassland, going north-east to the districts of Beaufort West and Colesberg, east to Uitenhage and then north to Aliwal North. In 1820, large numbers of British settlers landed at Port Elizabeth and settled in Albany and adjacent districts. In 1836 there was a general exodus of the Voortrekkers from the Cape Colony into the Orange Free State and the Transvaal, going north from Aliwal North and Colesberg through Bloemfontein towards Potchefstroom. While some went further north towards Louis Trichardt, others trekked east and down into Natal which had largely been depopulated by the conquering Zulus. Meanwhile the British had landed at Port Natal in 1838 and colonized the interior, pushing west and north from the coast (see map 1).

This sketch shows that the major part of the country has been farmed by Europeans for only just over a century. Records of the Voortrekkers and of travellers through different parts of the country about a century ago reveal a very different state of affairs from what we have to-day. They recorded descriptions of beautiful grassland where we have the Eastern Mixed Karoo to-day (see maps 2 and 3), well watered grassland in what are now regarded as the dry sections of the central Orange Free State and Western Transvaal and, in Natal, their first settlements took place in parts that to-day exhibit almost desert conditions. There has been an enormous change in the vegetation of the country which has resulted in severe erosion followed by floods and droughts throughout the land.

Droughts became so serious that a special Commission, known as the Drought Investigation Commission, was appointed to investigate the causes of drought. Its findings were published in its report in 1922.

Amongst the findings in part of the summary of Chapter 2 on rainfall it states "While the mean annual rainfall remains constant, its economic value has to a very great extent been reduced by the alteration in the properties of the surface of the country, for which man is responsible. In this reduced utility of rainfall must be sought the secret of our droughts." Chapters are also devoted to overstocking, deterioration of vegetal covering,

soil erosion and the necessity of improvement in farming methods and conditions. Among the recommendations of the Committee were "the adoption by the State of its responsibilities in the control of soil erosion" and the investigation by the Agricultural Department of certain grazing and fodder problems.

Jacks and Whyte, in "The Rape of the Earth," stated that "South Africa is in greater danger of catastrophe due to soil erosion than any other country in the world," while Dr. Ross, Director of Soil Conservation and Extension in the Union of South Africa has estimated that the productivity of the Union has dropped by 25 per cent in the last 25 years due to soil erosion.

Dr. C. R. van der Merwe submitted a communication on erosion and soil conservation in Joint Publication No. 25 (p. 67), (Jacks and Whyte, 1938) dealing with the various causes of erosion and proposed methods of combating it. He stated that "all economic and political measures, however, are useless unless they are supplementary to *controlled veld management* which is the crux of the whole problem."

Various other workers dealing with this subject have all stressed the need, in dealing with soil erosion and soil deterioration, for proper methods of conserving the vegetation, and a great deal of investigation has been done in this connexion. In addition the need for conservation has, of recent years, been so blazoned forth that public opinion has become "conservation-conscious" and, now that it is appreciated that conservation of vegetation must go hand in hand with soil conservation, it is likely that big strides will be made in the future.

EARLIER ATTEMPTS AT CONSERVATION OF VEGETATION

The need for the conservation of vegetation was, however, realized as early as 1792 when a proclamation was issued containing "Regulations respecting Woodcutting." In 1847, felling of trees in the forests of the Cape Midlands Conservancy was declared to be illegal and one conservator and four rangers were appointed to enforce this regulation. Despite this, it was almost impossible to stop the exploitation of the forests which were becoming seriously depleted. In 1880 Comte de Vasselot de Regne was appointed to a post of Superintendent of Woods and Forests and he, with the assistance of Capt. Harrison, conservator of the Midland Forests drew up a report recommending a system of managing the forests. This can be regarded as the first attempt at the scientific management of forests in South Africa.

Prior to the Union of the four provinces in 1910, there was no settled policy outside the Cape Province as regards protection and management of forests although men like Fourcade, Schoeflin and Sim made recommendations as to the management and protection of natural forests in Natal.

The Union Forests Act of 1913 provided legislation for the protection of Crown forests throughout the Union. The Forest Department also inaugurated the establishment of huge plantations of useful exotic trees in different parts of the Union. In latter years it has acquired big areas on the mountains in different parts of the Union in order to conserve the vegetation

and thus by protecting the water sheds and sources of the rivers, to ensure a permanent supply of water in them.

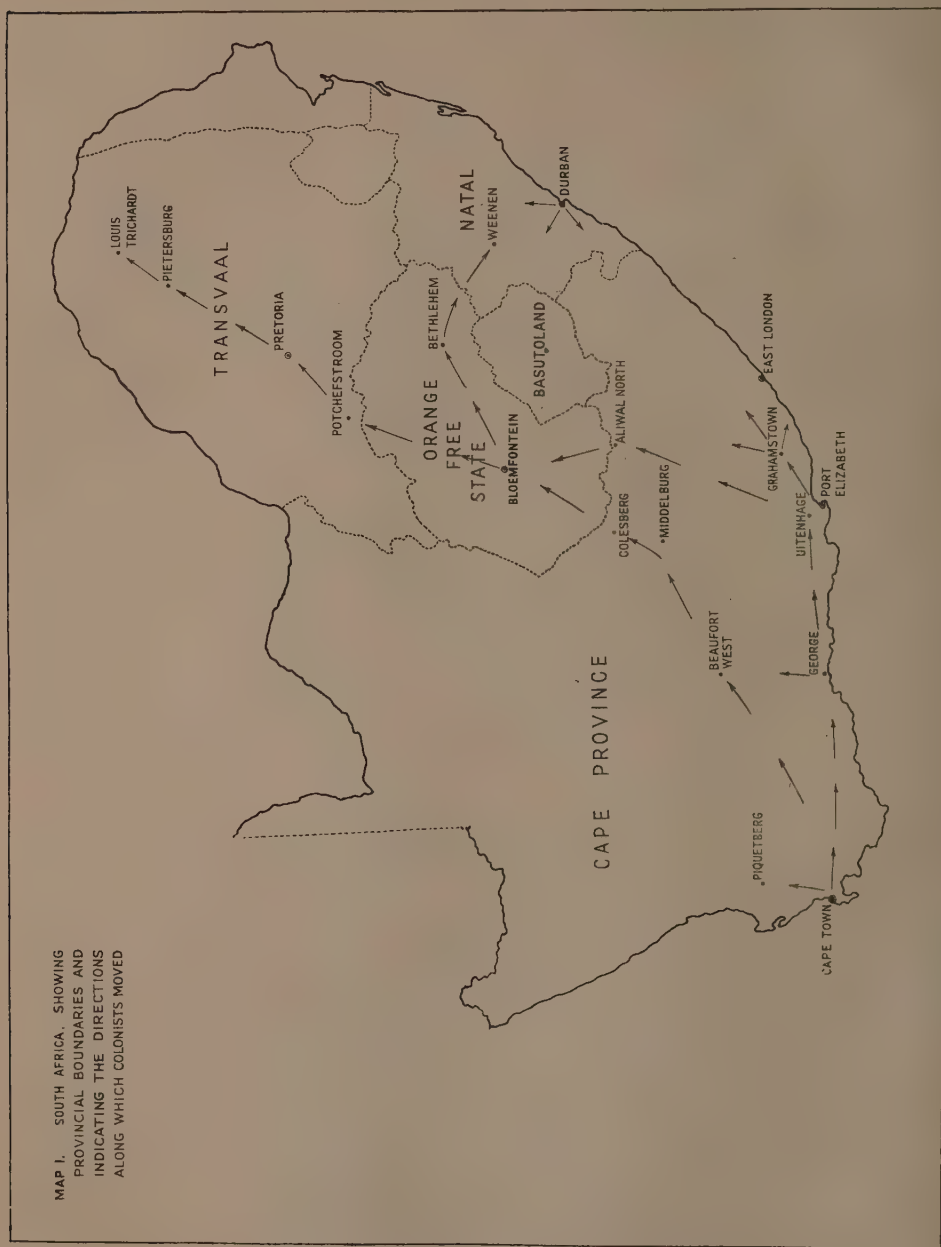
The forests, then, were the focal point of vegetation conservation in the earlier days mainly perhaps because they were of economic importance and their wholesale destruction was imminent. That they were not the only areas in which attempts at protection had been made, however, can be seen by reference to various acts and ordinances passed in all four provinces, prior to union. The Cape passed an ordinance in 1846 "for preventing the mischiefs arising from the cutting, rooting up and destroying trees, shrubs and bushes growing on the Cape Flats." Natal passed laws regarding the burning of veld in 1865 and 1869. The Transvaal and Orange Free State also passed laws regarding the burning of veld in 1895 and 1908 respectively.

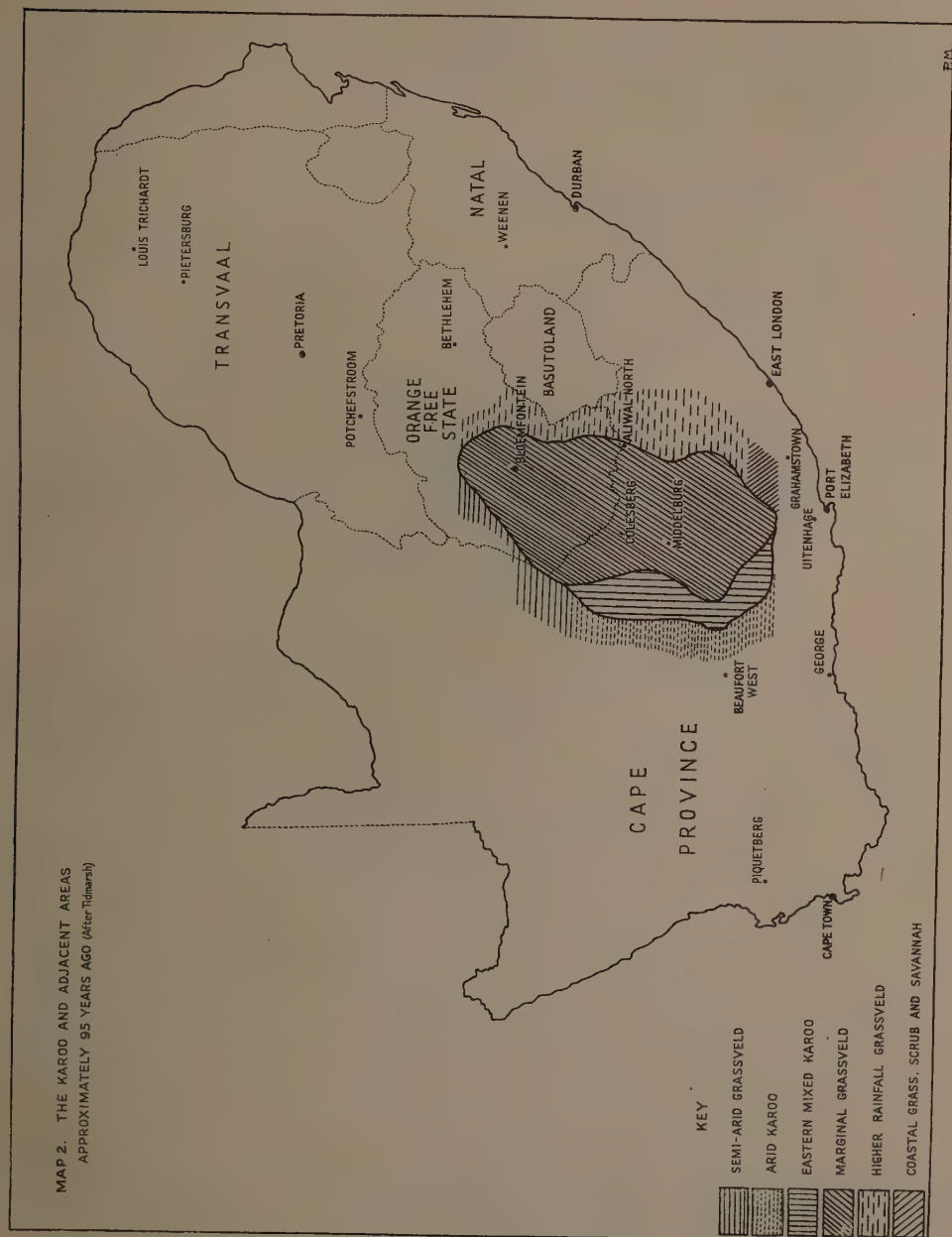
Thus, from the earliest days there were attempts to conserve the forests and protect the vegetation against widespread burning.

In 1918 the Botanical Survey of the Union was established under the direction of Dr. I. B. Pole Evans. This survey made it possible to delimit the extent and distribution of the various types of vegetation and to obtain much information on the state of the vegetation in the different parts of the country. In 1920 Pole Evans produced his first vegetation map of the Union and, in 1935, he published in Botanical Memoir No. 15 another vegetation map of the Union, bringing the Botanical Survey work up-to-date and providing the basis for further detailed investigations. Pole Evans, with his unique knowledge of the vegetation of the Union, realized that the veld throughout the country was being excessively exploited due mainly to a lack of knowledge of its potentialities and the management necessary to conserve its resources. With characteristic vision he inaugurated a scheme of grassland research on the results of which most conservation of vegetation in the Union is to-day based.

This work was initiated by a series of veld surveys throughout the Union followed by establishment of grassland research stations in the Bushveld of the Transvaal, the marginal maize area of the Transvaal and Orange Free State, the "sourveld" of the Eastern Transvaal, and different parts of Natal, the Eastern Cape Province, Border, and Griqualand West. From these research stations the Botanical Survey was extended in detail throughout the areas served by the respective stations and a great deal of research work was carried out on the establishment of principles of veld management, veld burning, and re-establishment of a good grass cover on damaged veld and abandoned agricultural lands. There are many important areas of the Union which are not yet served by research stations, but the results obtained from the research on those stations which have been established are being applied with success. There is every reason to believe that, as these results are put into practice generally, not only will soil erosion be prevented and the conservation of vegetation increased but the general productivity of the country will rise once more.

One of the aspects of conservation of vegetation which has received attention throughout has been the effect of veld burning. The results obtained will be discussed here before going on to the principles of veld management which have been established for the different ecological areas.





VELD BURNING

Pole Evans divided the vegetation of South Africa into four main types—Forest, Parkland, Grassland and Desert Shrub—each with a number of sub-divisions, namely (see map 4),

Forests

1. Evergreen and Deciduous Bush and Sub-tropical Forest.
2. Temperate Evergreen Forests.
3. Evergreen Sclerophyllous Bush.

Parkland

1. Evergreen and Deciduous Tree and Bush.
2. Sub-tropical Evergreen and Deciduous Tree and Thorn Forest.
3. Thorn Country.

Grassland

1. Tall Grass.
2. Short Grass.
3. Mixed Grass.

Desert Shrub

1. Thorn Country and Desert Shrub.
2. Desert Shrub.
3. Desert Succulents and Desert Grass.

As far as veld burning is concerned, it does not occur much in Desert Shrub country and, where it has occurred, it has always done a great deal of damage.

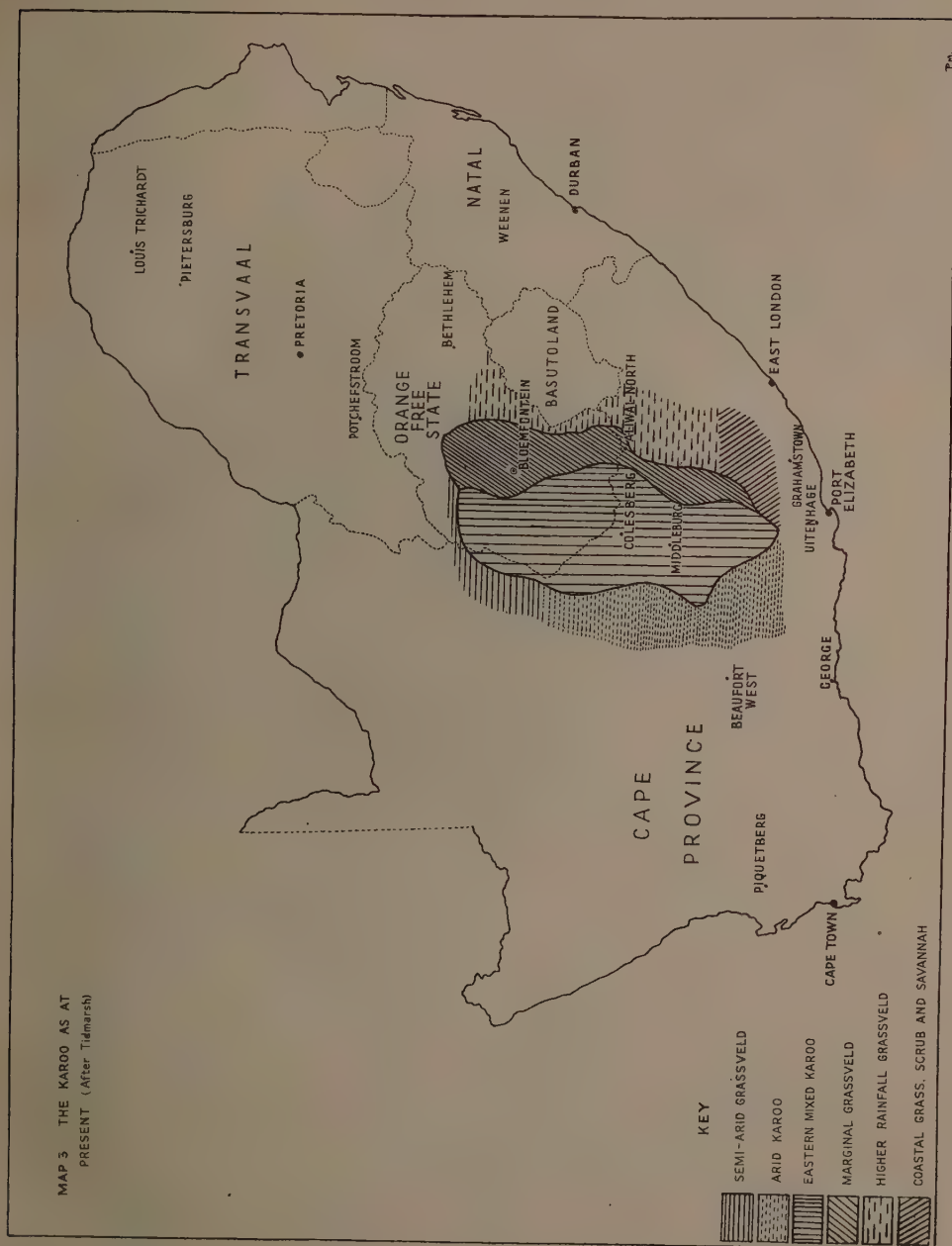
In areas of Evergreen and Deciduous Bush and Sub-tropical Forest and of Temperate Evergreen Forests, fire has always brought about a great deal of destruction. Not only have some fires completely wiped out large tracts of forests which have never become re-established, but great efforts have to be made annually by the Forests Department to control veld burning on the margins of forests. Here, as in the case of Desert Shrub, fire destroys the vegetation and nothing can be said in favour of burning.

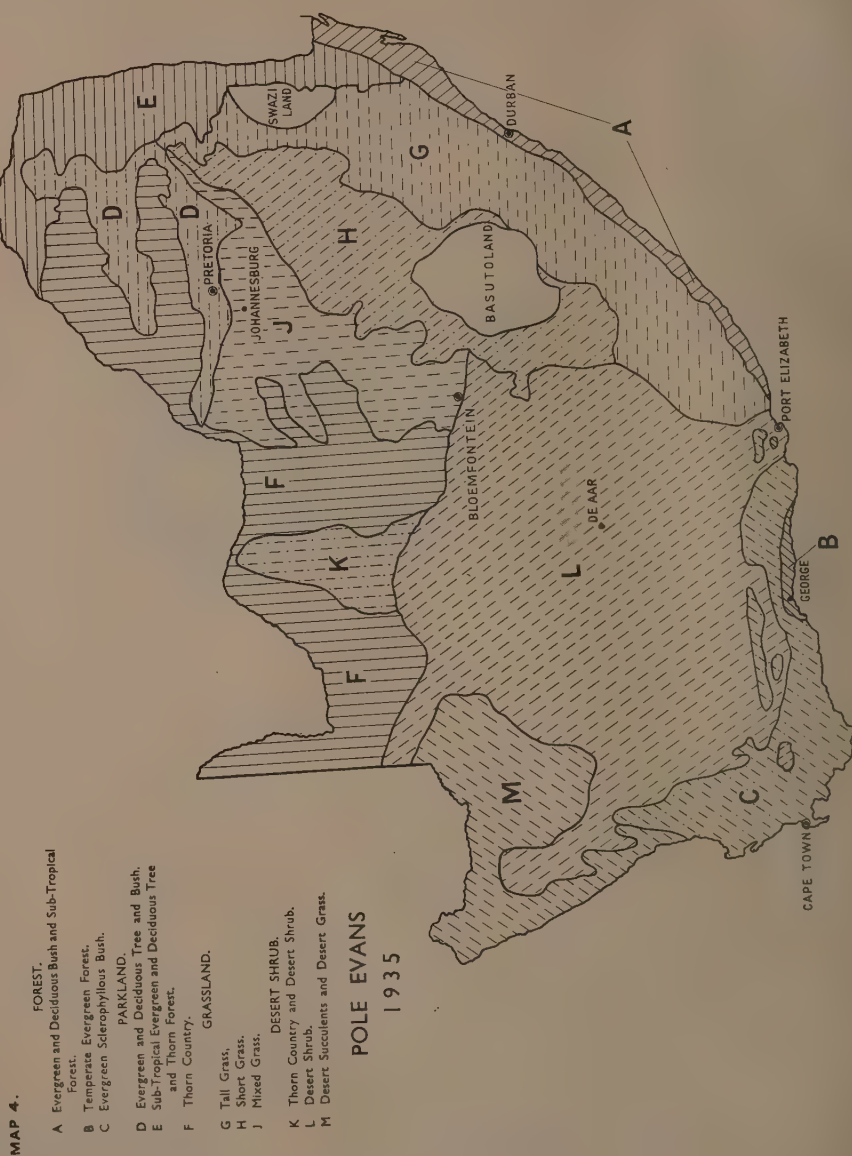
It is when the areas of Sclerophyllous Evergreen Bush, Parkland and Grassland are encountered that the subject of veld burning becomes a controversial matter. In all these areas veld burning has been a practice for many years and many people maintain that it is necessary to burn while others are equally definite that veld burning should be considered a criminal offence. Research has thrown much light on the subject.

As it is on account of the grass that the Parkland is burned, Parkland and Grassland will be considered together in this discussion on veld burning while Sclerophyllous Evergreen Bush will be considered separately.

Grassland and Parkland can be divided roughly into three main types as regards the palatability of the grazing; these types are known as "Sour veld," "Sweet veld" and "Mixed veld."

In Sour veld the grasses are unpalatable to stock on reaching maturity even though this may be comparatively early in the growing season. In





Sweet veld the grasses are palatable after reaching maturity and may remain palatable, not only in the dormant season but in the following growing seasons. Mixed velds may have varying combinations of the two types of grasses.

Those who make a practice of burning veld in their farming operations claim that it is necessary for a number of different reasons, the chief of which are :—

- (a) control of ticks and other insects which transmit stock diseases ;
- (b) production of green grazing in early spring ;
- (c) production of young palatable green grazing just before the winter in Sour velds ;
- (d) removal of old grass which has been left by stock and which, if left in subsequent seasons, will not be taken by stock and will become moribund and die out ;
- (e) control of undesirable plants in the veld.

As a result of the investigations made in the different areas, it has been established that only the last two reasons have any sound justification and then only under certain conditions. Had it been possible to control ticks and other insects by burning, they should have been completely wiped out in many areas long ago owing to the widespread burning which took place. They could be far better dealt with by properly controlled dipping.

Burning in the winter is quite a common feature in the high rainfall Sour veld areas where there often is enough moisture to start the grass growing, but it is a bad practice because, as often as not, there is not enough moisture to keep the grass growing or such growth as occurs is frosted off with much damage to the plant cover. The burned areas remain bare for a long period thereby increasing the chance of erosion, particularly wind erosion, while the grasses, when they do receive sufficient warmth and moisture for growth, rush into seed and produce very little leaf due to loss of vigour.

Burning in the late summer or autumn to obtain green grazing before the winter is a most reprehensible practice. It is usually carried out in Sour veld areas by sheep farmers who are unable or unwilling to provide the necessary winter feed on arable land. The grass is burned off at the time when the food stored in the leaves is being transferred to the roots to build up reserves for growth in the following season. At the same time the stimulus of the fire causes growth which depletes the roots of the reserves already stored and this green growth is grazed off short. There is not adequate protection for the soil in the winter and serious sheet erosion occurs, due particularly to wind, while the vigour of the grass growth in following seasons is so impaired that non-desirable plants usually invade the veld. This has been found to occur whenever autumn burning takes place, even at intervals of 2 or 3 years.

In Sour or Mixed velds, it is not possible to graze the veld uniformly every season without overstocking and causing veld deterioration. Grass must have rest at certain times during the growing season if it is to persist and be productive. Under these conditions there is always a good deal of

grass which is not grazed. If this is not removed by some means, the stock will not touch it the next season and, by the third season, the untouched tufts become moribund and begin to die. Should such a veld be accidentally burned after a few years, the fire smoulders in the dead tufts, burning right down into the roots and damaging the soil. It may take years to revegetate such areas.

The only methods of removing this old grass are by mowing or burning. It has been established that, if it is possible to mow the veld, removal of old dead grass by such means at the end of the winter is not only the best method of conserving the vegetation in a healthy state but it causes the grass cover to thicken up considerably. Such grass, mown at the end of winter, provides earlier grazing in the spring and produces far heavier hay yields than veld treated in any other way. Where it is not possible to mow, it is necessary to remove the old dead grass by burning at the correct time. As indicated earlier, burning in winter or in autumn is very harmful but it has not been possible to establish harmful effects from burning in the spring after rain has fallen. This ensures that there is sufficient moisture in the soil to keep the grass growing and thus the soil surface is left exposed to insolation for a minimum period of time. While this burning is not as beneficial as the mowing, the veld remains healthy and vigorous. Periods between burns depend on the amount of old grass to be removed but burning once in 2 years after spring rains is usually regarded as a safe practice.

In Sweet velds it should not be necessary to burn the veld at all for the removal of old grass because it should be possible to manage the veld in such a way that stock will remove the grass themselves as it does not become unpalatable. Thus burning of Sweet veld is to be discouraged as far as possible except where, due to an upset in the natural balance by some factor, there is an encroachment of undesirable plants.

In many Parkland areas there is an encroachment by Thorn Scrub which becomes so dense that, in competition for water and nutrients, the grasses tend to disappear entirely and the soil is left bare under the Scrub. Stands of two thousand or more young Acacias per acre form dense impenetrable thickets and, with the disappearance of the grass, the soil under the thickets begins to erode. Such vegetation is useless from a grazing, soil, or water conservation point of view and has to be kept in check. Similar examples can be found of the encroachment of other undesirable plants in grassland areas.

Where the invading scrub is very dense, it has to be destroyed by some means—mechanical or chemical—before a grass cover can be re-established. Once the cover has been re-established it is necessary to manage it in such a way that any further encroachment can be checked. It has been found necessary, in such cases, to employ fire. The veld is rested in the previous autumn to permit the build up of root reserves and to give plenty of material for a fire. In the winter it is not grazed; it is burned off in the spring after rains, and then rested until a good grass cover has appeared. The grass is unaffected by the fire but the young Thorn Scrub is badly damaged, and helped by a rest following the fire, the grass is able to compete successfully for water, light and nutrients. Such burning of the veld should take place at intervals of 2 years or more and only in spring after rains.

The burning of Sclerophyllous Bush in the winter rainfall areas of the Cape has also been a matter of controversy for many years. The Bush itself is not palatable to livestock except where burning is practised and grazing and browsing take place on the young regrowth. There is no doubt that the vegetation of the South West Cape Province is deteriorating rapidly, due mainly to burning and grazing practices. Recently the Royal Society of South Africa appointed a committee to report on the Preservation of the Vegetation of the South Western Cape; the following statements are quoted from its report :—

“ Total protection from burning appears to be needed to conserve water and soil but, if this treatment were carried out universally, the costs would be prohibitive and there is doubt as to whether total protection everywhere is a practical possibility. Evidence exists in favour of controlled burning in order to reduce the inflammability of the vegetation and to promote lavish displays of flowering geophytic plants in selected areas but such burning should never be followed by sustained pasturing. Pasturing on the steep, acid mountain lands of the Cape is barely profitable and invariably leads to destruction of vegetation and erosion.”

Later the report states :

“ It is recommended that large representative national reserves, as well as local reserves, should be established on which all efforts to maintain the vegetation in an unaltered natural state should be concentrated. Outside these reserves the standard practice should meanwhile be the deliberate, rotational burning of prescribed areas—controlled burning. All sustained pasturing should however, be stopped and erosion checked wherever it occurs. Complete protection from fire, usually accepted as a universal remedy, should be applied only in specially selected stream and river catchments which yield valuable water supplies.”

It appears then that in both Grassland (including Parkland) and Sclerophyllous Bush, fire may be necessary under certain conditions, but its widespread use or a wholesale condemnation of its use are equally erroneous.

GRAZING MANAGEMENT

Until fairly recently, most farmers looked upon the veld as the part of the farm which provided grazing for their stock but the idea that it deserved any special treatment was strange to them. Almost the only management it received was to be burnt off in spring and grazed all summer; then, if it happened to be a Sour veld, the stock were trekked to a Sweet veld for the winter and brought back the following spring. Otherwise farms might have summer and winter paddocks depending on the sweetness of the veld and the availability of water.

When the Europeans first came into the interior, enormous herds of game used to move across the country, usually following rain in the summer, grazing veld right down and then, by moving on, allowing it to rest and

recuperate. In the winter they trekked back to sweeter veld. This natural form of management maintained the veld in good heart. With the heavy concentration of the herds of game, there was not much opportunity for selective grazing and, in Sour veld, the grass was grazed right down and then left to rest.

When the European began to farm and the game disappeared, the stock was confined within the limits of the farm, but there was no heavy grazing followed by rest. Instead there was much lighter grazing over bigger areas for longer periods and no periods of complete rest during the growing season. Thus in Sour and Mixed velds the more palatable grasses were overgrazed while the more unpalatable types were left. This selective grazing led to big changes in the veld.

Patches of sweeter grasses were kept short and gradually disappeared and thus retrogression set in. The unpalatable grasses were burned off each year, usually far too early, with the result that the soil was exposed to insolation and wind erosion took its toll. The grass cover became poorer, less water was able to penetrate before running off and the process of desiccation set in.

Research on veld management and restoration of veld has established various principles. Firstly, there are certain periods during the growing season of the grasses when a rest from grazing is essential and these periods vary from one type to another.

In Sweet velds, as a rule, damage can be caused by heavy grazing in the summer. There are three or more critical periods in the growth of such veld. Firstly in the spring, when the grasses are beginning to grow, they draw on their roots for reserves stored the previous season. If grazed too heavily at that time, the root reserves may become depleted before the plants are well established and so the veld loses vigour. The principal grasses also require an opportunity to seed, either in early summer, mid-summer or late summer. Finally, a rest in the autumn when the grasses are transferring reserves from the leaves to their roots enables the roots to build up a good store of reserves to provide for early and vigorous growth the next season. Winter grazing does not affect the grasses to any extent. Systems of rotational grazing have been evolved so that certain paddocks are rested in spring while others are grazed, others are rested at the seeding time of the principal grasses and others are given rest in the autumn. With a rotation every paddock has a rest at one or other critical growth period in a given cycle of years. Irvine, at the Towoomba Research Station in the Transvaal Bushveld, worked out a number of systems to suit different veld types using two herds to each series of five camps in a 5 year rotation. Other systems have been evolved by the writer and other workers in their particular areas.

In Sour veld a spring rest is not so necessary because it leads to extremely selective grazing. Autumn rests are enforced by Nature as the veld becomes so unpalatable, although this often does not occur until the better, more palatable types have been severely punished. In such veld it is better to have rotational systems in which there is very heavy grazing for short periods with rests to allow the grasses to recuperate. Certain paddocks are reserved for haymaking while one in every five receives a full season's rest. A

complete rest one year in five gives opportunities for reseeding and the total season's growth can be removed by mower or fire in the following spring.

Botha, at the Athole Research Station in the Sour veld of the Eastern Transvaal, has evolved suitable grazing systems for the Sour veld.

In Mixed veld, rotational grazing systems allowing rests at the critical growth periods have been evolved by the writer in Natal and others elsewhere (Scott, 1947).

In addition to the grazing systems which allow the veld to rest at certain seasons, the mowing machine, used to control the veld instead of burning and also for the cutting of hay in rotation with grazing, has led to vastly improved veld management. Restoration of veld in areas where retrogression has taken place has also received much attention. In certain Sweet veld areas, the resting of the veld in summer with grazing in winter has led to recovery of the veld. In others, particularly in Sour and Mixed velds, the use of the mowing machine coupled with rotational grazing restored the veld while in others it has been found necessary to reseed before grasses could be re-established.

There is no doubt that good veld management will not only provide far greater and steadier production from the veld but that it also maintains a good vegetal cover and conserves the vegetation at its optimum stage.

Work on grass leys to restore soil fertility and, at the same time, to provide a useful grazing crop in a rotation on arable land is still in its infancy in this country. A great deal of work on suitable types of grasses and their management is necessary.

LAND USE

Recently the planning of land use has received a great deal of attention in different parts of the world. Pentz, on the basis of his botanical and erosion surveys in Natal (1938, 1945) pointed out that almost invariably erosion and veld deterioration followed on the application of incorrect farming systems. He maintains that, in every area, the ecological conditions, particularly distribution of rainfall, soil type, topography and vegetation should determine whether that area is suited to extensive farming (where total reliance for production is on the natural veld), semi-intensive farming (where most of the reliance for production is on the veld which is merely supplemented by arable land) or intensive farming (where reliance for production is mainly on arable land, whether in the form of crops, pastures, or both). When land deterioration in the Union is studied, it is usually found that the greatest amount has occurred where areas, which are really suitable only for extensive or semi-intensive farming, have been used for intensive farming. Pentz makes the plea that surveys of the potentialities of the whole Union should be made from the aspect of planning agriculture or land use on the basis of ecological conditions. Once the land use survey for each area has been made, it will be obvious what part the veld or planted pastures should play in the farming system, and thus the best methods of conserving the vegetation would lead to improved production and the removal of the causes of erosion.

VEGETATION IN NATIVE AREAS

The destruction of vegetation and resultant soil erosion is probably greater in the native reserves than in other parts of the Union. This is not surprising when the history of the natives and the reserves is traced.

Before the advent of the White Man, the Bantu had moved down the East Coast of Africa, always moving farther and farther south till eventually they clashed with the European settlers who were moving eastwards. The Bantu were mainly pastoralists and such cultivation as was practised took the form of shifting cultivation. It is believed that a great deal of forest country was changed by them into grassland along the Eastern portions of Natal, East Griqualand and the Transkei. With cutting down of bush to allow of cultivation which, after a few seasons, was allowed to revert to grass or destruction of the bush by fire, grassland replaced the bush. While shifting cultivation may have destroyed much bush or forest which was then kept from reverting back to bush again by means of fire, there was still a good vegetal cover throughout these areas. The Bantu had largely wiped out the former inhabitants of the country and it was not until they clashed with the Europeans that their advance along the coast was checked. Then a number of wars, spread over nearly a century, resulted in the natives having to settle permanently in certain areas. While some of these areas were among the best parts of the Union, many native reserves were scattered through different parts of the country without any idea of suitability of the land for native occupation. Some of these reserves were in high-rainfall areas with poor, leached soils which call for the most skilled intensive farming quite beyond the capacities of the primitive native. In those days it was a matter of settling them where there would be least likelihood of further clashes.

The first result of the natives having to settle in fixed areas was that they could not use land and then move on to another area as they had done in the past. Thus they had to keep their stock in the same areas and cultivate the same lands but they did not alter their primitive methods. As the population increased, the pressure on the land increased as well, and during recent years erosion has become very serious indeed; grass in the areas of better rainfall has been replaced by inferior, useless plants, water supplies have diminished and supplies of timber for firewood or hut building have become exhausted.

The reasons are mainly overstocking, no system of veld management and bad agronomic practices. Overstocking has come about through ordinary increase in stock caused by the native's inherent love for cattle in large numbers—this being the measure of his wealth—and protective measures against stock disease. At the same time there has been a big increase in native population all of whom are imbued with the idea of possessing stock. There has also been excessive increase in the amount of small stock.

Absence of veld management has been due to a lack of knowledge for the need thereof, and the system of domicile of the people within the common grazing grounds.

Bad agronomic practices were due to the fact that the natives could no longer practise shifting cultivation, and the meaning of fertility and its

maintenance was far beyond their ken ; their diet was mainly maize or kaffircorn (*Sorghum*) and these were the only crops grown, year after year, without rotation.

The difficulty of tackling these problems in the native areas is that they are bound up with primitive customs and beliefs. The fact that a good cow producing enough milk for a number of humans and her calf is better than two which barely produce enough milk for their calves is not acceptable to them as *cattle numbers* are their basis of wealth. Their systems of domicile in small groups of huts within the grazing areas and their antagonism against shifting towards planned residential areas which would release much grazing and make veld management a practical proposition are further complications. As often as not, natives who have had training in better agricultural methods will revert back to the primitive methods of their fathers when they return to the Reserves, because the women and children actually do the work. Finally, although a very large percentage of the natives work in the mines, industries or in towns away from the Reserves, returning only at intervals, their families are domiciled in the Reserves and still expect to have the same land and keep the same amount of stock (if not more) as the bona fide native farmers in the Reserve.

Until those natives who earn their subsistence outside the Reserves and are no longer real agriculturists become domiciled either where they work or in rural villages in the Reserves and so release land for agriculture and grazing for use by the bona fide native farmers, the Reserves will continue to be overpopulated and overstocked.

As it is, the migratory labour system has probably saved the Reserves from famine on many occasions. The fact that a large proportion of the men worked on the mines, in industries or in the towns and earned the wherewithal to tide themselves and their families through periods of shortage probably saved them from starvation. On the other hand, not only did it provide them with the means to purchase more cattle which has led to the overstocking of the land but it postponed the realization that, unless they changed their primitive methods, starvation and famine would force them off the land.

If the native population can reach the stage where the true agriculturist works and manages the land and veld, and the industrial native no longer expects to be a land user as well, a very big step forward will have been taken. Until then every effort at prevention of overstocking, proper management of veld and improved methods of cultivation will be stultified.

The Department of Native Affairs is making big efforts to assist and educate the natives to a realization of the need for tackling deterioration of soil and vegetation and has spent a great deal on soil erosion control works, particularly contouring of lands. It is also making big efforts to educate them to the need for reducing stock numbers, producing better stock and improving cultivation methods. Whether the natives will respond before complete destruction of soil and vegetation forces them off the land remains to be seen.

RECENT LEGISLATION FOR CONSERVATION OF VEGETATION

Advances in our knowledge of the causes of soil erosion, the effects of fire and mismanagement of grazing and the fact that conservation of vegetation, water and soil are intimately bound up have led to a demand that the findings of research should be applied throughout the country. While much research is still needed in those areas where it has been carried out for some years, many areas are still in need of a great deal of research work.

The fact, however, that the productivity of the country has decreased by such alarming proportions in the past few decades due to soil erosion and that this is linked up with destruction of the vegetation has made the European population "conservation-conscious", with the result that legislation to apply whatever knowledge is available, before it is too late, has been passed.

The Forest and Veld Conservation Act of 1941 repealed most of the earlier legislation on the subject of conservation of forests and other vegetation and replaced it with comprehensive legislation "to amend and consolidate the laws in the Union relating to the tenure, demarcation, management and utilization of forests and the regulation of veld burning . . . and to make better provision for veld, soil and water conservation."

This legislation made provision for the protection of Crown Forests and of different types of trees with regard to felling or removal, for regulation of veld burning and the management of grazing or cultivation on land controlled by the Department of Forestry. It also allowed for the expropriation of privately owned land for

- (a) the conservation of Crown forests or plantations ; or
- (b) the prevention of sand drift or the reclamation of land affected thereby ; or
- (c) the prevention of soil erosion or the reclamation of land affected thereby ; or
- (d) the protection of catchment areas or the conservation of water sources.

It also allowed for the proclamation of Conservation Areas in which land should be reclaimed or conserved at public expense.

This legislation was a big step in the right direction and two Conservation Areas were proclaimed in 1943 and 1944. Within these areas the State has carried out much work in the reclamation of eroded areas and the re-establishment and protection of vegetation. In addition farmers were encouraged by means of loans or bonuses to practise conservation farming. As this might entail change in farming systems, alteration or erection of paddock fencing and various other changes in addition to anti-erosion measures, liberal bonus and loan facilities were granted.

In June 1946 a new Soil Conservation Act was passed. The objects of this Act were :—

" To make better provision for the combating and prevention of soil erosion and for the conservation, protection and improvement of

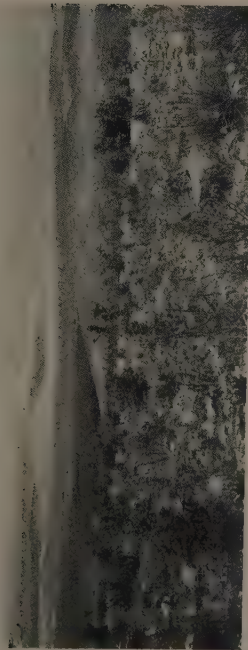


FIG. 1.—Burned sclerophyllous bush in the winter-rainfall area of Cape Province, showing denudation of the veld.
J. D. Scott.

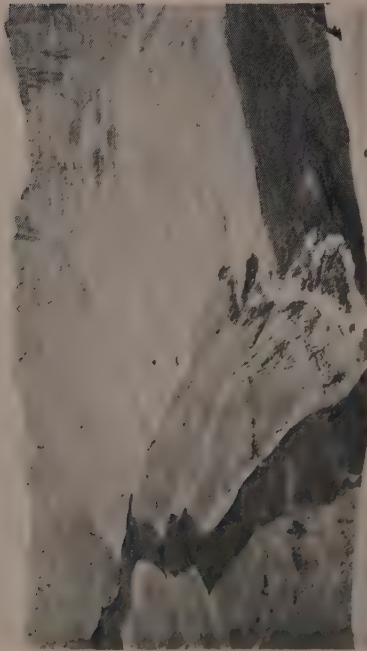
FIG. 2.—Grassveld in the Eastern Cape Province invaded by rhinoceros (*Elytropappus rhinocerotis*), which can be controlled by judicious burning and subsequent management.
J. D. Scott.



FIG. 3.—Grassveld invaded by low-growing thorn scrub, which prevents grazing and ultimately eradicates the grass.
J. D. Scott.

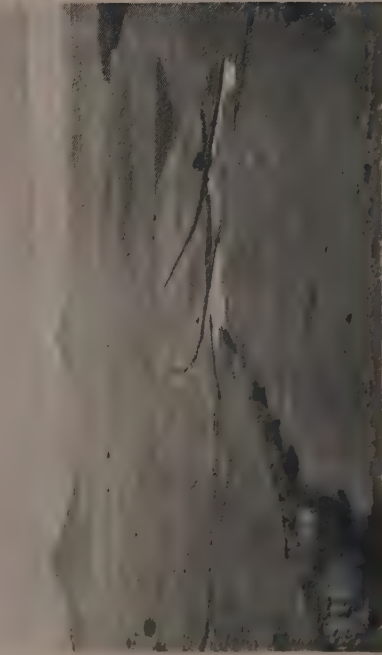


FIG. 4.—Fire belts nearly half a mile wide to protect mountain areas against uncontrolled fires.
J. D. Scott.



J. D. Scott.
FIG. 5.—Fire belts nearly half a mile wide to protect mountain areas against uncontrolled fires.

J. D. Scott.
FIG. 6.—Well-grassed country in Natal which appears to have been under evergreen forest until recent years. Veld burning now restricts the forest today to protected ravines and valleys.



J. D. Scott.
FIG. 7.—Conservation of water and of vegetation go hand in hand on a farm in the Orange Free State.

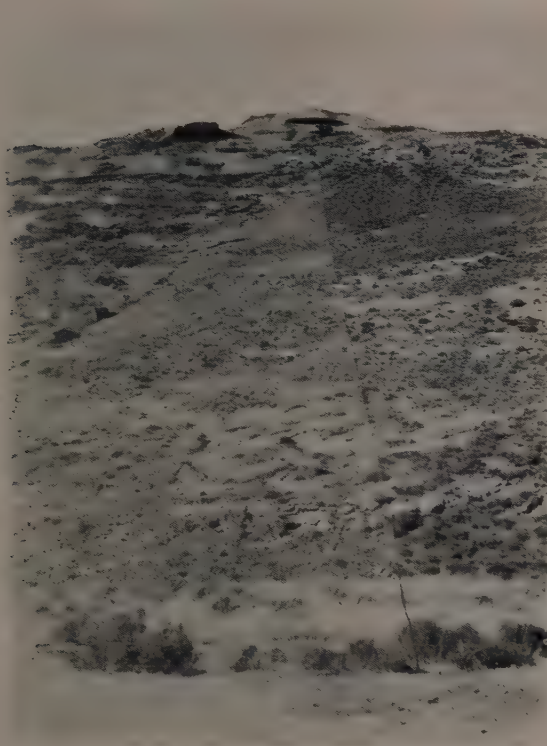


J. D. Scott.
FIG. 8.—Grass cover has disappeared owing to uncontrolled grazing on this farm in the Transvaal bushveld.



J. D. Scott.

FIG. 9.—Grass cover has been reduced and largely replaced by small shrubs over large areas in the Orange Free State, due to uncontrolled grazing.



J. D. Scott.

FIG. 10.—Differences in vegetation on adjoining farms in Cape Province due to differences in veld management.



FIG. 11.

J. D. Scott.



J. D. Scott.

FIGS. 11 and 12.—Grass cover has disappeared due to uncontrolled grazing and cultivation by dense native populations in this part of the thornveld of Natal.



M. J. von Krosigk.

FIG. 13.- Plantations of *Populus* and *Salix* which were established in Northern Transbaikalia along the watershed are now being destroyed in order to restore the flow of waters in rivers which have dried up since these plantations were planted.

the veld, and the soil, the surface of the land, the vegetation and the sources and resources of the water supplies in the Union ; to amend the Forest Act 1941 ; and to provide for other matters incidental thereto."

This Act amended the Forest Act of 1941 as far as provision regarding soil erosion and protection of vegetation and water sources was concerned. In addition it made provision for very far-reaching changes in the methods of conservation in the Union. First, it allowed the establishment of a Soil Conservation Board to co-ordinate and control all conservation work in the Union. Then it provided for the establishment of Soil Conservation Districts in which special District Committees, consisting mainly of farmers in those districts, would be responsible for the drawing up of conservation schemes for every farm in the district. Such conservation schemes might include provisions amongst others relating to :—

- (1) the soil conservation measures which shall be applied in respect of the land and the order in which they shall be applied ;
- (2) the manner in which land shall be prepared for sowing or planting including provisions relating to rotation of crops or strip cropping ;
- (3) the temporary withdrawal from cultivation or grazing of any defined portion of land for specified periods ;
- (4) the restriction of the numbers or kinds of livestock which may for any specified period be grazed on any defined portion of land ;
- (5) regulation or prohibition of veld burning ;
- (6) the treatment and management of forests and plantations including the disposal of slash, debris or waste ;
- (7) generally the prevention of soil erosion, the conservation, protection and improvement of the veld, the soil, the surface of the land, the vegetation and the sources and resources of the water supplies on the land.

Here too, liberal allowances are made in the form of loans and bonuses to enable farmers and landowners to change over to systems of conservation farming and thus conserve the soil and the vegetation.

CONCLUSIONS

It is evident that, although untold damage has occurred to the vegetation and soils of the Union during the last century, the European population has been awakened to the necessity of nation-wide conservation measures. If the legislation which has been enacted in the past few years is applied on the wide scale envisaged and if the land-owners of the Union will make use of the facilities which have been made available, the conservation of vegetation in the European-owned areas will assist not only in restoring the vegetation to its former condition but will lead to increase of water supplies and the control of erosion.

Whether the native areas will be saved will depend on whether the native population can be made conscious enough of the fact that, unless

something is done, their means of subsistence in those areas will disappear entirely. A serious matter for the country is that many native areas are on the watersheds and in the main catchment areas of the principal rivers and their primitive practices affect water supplies of areas far removed from them.

SUMMARY

The history of the early colonization of South Africa indicates that the natural vegetation has been largely destroyed or damaged in the course of one century.

Since the early settlement days there have been those who realized the danger of the destruction of the vegetation, particularly with reference to the forests and attempts have been made to protect the vegetation.

Later, the inauguration of the Botanical Survey led to a knowledge of the distribution of the vegetation and its resources as well as the damage which it was suffering.

The establishment of Grassland Research Stations produced results on the effects of veld burning, veld management and conservation farming which to-day act as a basis for most conservation farming.

Planned land utilization based on ecological conditions with a view to eliminating land use which causes erosion and destruction of vegetation is indicated as the proper basis for all conservation of soil and vegetation.

The problems of soil and vegetation conservation in the native areas are bound up with primitive customs and beliefs and, unless natives are educated beyond them, no conservation measures can succeed.

Recent legislation allows for the tackling of vegetation and soil conservation on a nation-wide scale.

BIBLIOGRAPHY.

- BOTHA, J. P. 1945. Veld management in the Eastern Transvaal. *Fmg S. Afr.* Vol. 20, pp. 537-41.
- FICK, J. C. 1944. The abuse of the soil. S. Afr. Interests Group Publication.
- IRVINE, L. O. F. 1941. Quinquennial report of the Towoomba Pasture Research Station, Warmbaths, Transvaal.
- JACKS, G. V., and WHYTE, R. O. 1938. Erosion and soil conservation. I. A. B. Joint Publ. No. 2. pp. 67-81.
- JACKS, G. V., and WHYTE, R. O. 1939. The rape of the earth. pp. 312. Faber and Faber, London.
- LAUGHTON, F. S. 1937. The silviculture of the indigenous forests of the Union of South Africa with special reference to the forests of Knysna region. Union of S. Afr. Dept. of Agric. and For. Sci. Bull. No. 157. Forestry Series No. 7. Pretoria.
- NORTON, J. A. 1947. Rehabilitation in native areas. *Veld Trust News*. Vol. 3. No. 6.
- PENTZ, J. A. 1938. The value of botanical survey and the mapping of vegetation as applied to farming systems in South Africa. *Bot. Survey of South Africa. Mem.* 19. pp. 15.
- PENTZ, J. A. 1945. An agro-ecological survey of Natal. Dept. Agric. For. Bull. 250.
- POLE EVANS, I. B. 1936. A vegetation map of South Africa. *Bot. Survey of South Africa Mem.* 15. pp. 23.
- SCOTT, J. D. 1947. Veld management in South Africa. Union of S. Afr. Dept. Agric. Sci. Bull. No. 278. pp. 40. Pretoria.
- SOUTH AFRICA. 1922. Drought Investigation Commission. Report.
- TIDMARSH, C. E. M. 1947. Conservation problems of the Karoo. Report of Agric. Res. Conference, Pretoria. 1947. *Fmg S. Afr.* Vol. 23. pp. 519-30.

- UNION OF SOUTH AFRICA. 1941. The Forest and Veld Conservation Act (Act No. 13 of 1941.)
- UNION OF SOUTH AFRICA. 1946. Soil Conservation Act (Act No. 45 of 1946).
- WICHT, C. L. 1945. Report of Committee on the Preservation of the Vegetation of the South Western Cape. Spec. Publ. of the Roy. Soc. of S. Afr. Cape Town.

II. THE VEGETATION IN RELATION TO SOIL AND WATER CONSERVATION IN EAST AFRICA

BY

D. C. EDWARDS

OVER considerable areas of East Africa the development of the vegetation is influenced by man, but marked change resulting in extensive soil degeneration is chiefly of recent origin. In the past, for instance, fire was used and it still is used by the pastoral tribes to retard the development of bush and maintain open grassland ; also it was a means by which, in some grassland regions, undesirable coarse herbage was suppressed in favour of more readily utilizable phases of the succession. The agricultural tribes were confined mainly to the forest regions where, under the conditions of relatively high rainfall, regeneration of the plant cover was able to keep pace with the clearance required for the production of food crops. Under the changed conditions brought about by increased population and the growth of wants associated with the advance of civilization, the former primitive methods of utilization are no longer capable of preserving a balance which avoids deterioration.

Destruction of the vegetal cover and consequent soil degradation arise from two main causes ; (a) the extension of forms of human occupation from the regions in which they have developed to regions of ecological conditions incapable of supporting these forms of occupation, and (b) the development of agricultural practices which result in undue exposure of the soil surface, both within the former habitat and in the areas which have been invaded.

These two causes of deterioration chiefly concern the native population, although the second is also of considerable importance under conditions of European farming, and the twofold problem has arisen as the direct result of development consequent upon the advent of Europeans into these territories. In the relatively short period of 50 years, inter-tribal warfare has ceased and a large measure of control has been attained over both human and animal diseases, resulting in a greatly increased population of men and animals. Further, with the removal of the threat of raids, occupation of the productive regions has become more stable and agriculture has gradually been intensified, but without any essential change in the methods employed to meet the changed conditions. The increasing pressure of population naturally results in a constant tendency on the part of the agricultural and semi-agricultural tribes to expand into areas which are ecologically incapable of supporting their mode of living. This process has been accentuated in recent years as the choice of areas in which to expand has become ever more limited. Until to-day, even the authorities concerned were sometimes forced

to consider the utilization of territory totally unsuited to the type of occupation proposed. It is obviously true that the major part of the soil erosion problem is concerned with land use which is incompatible with the ecological conditions, but this is particularly true of the expansion of crop production into regions of marginal conditions.

A consideration of the plant communities described below reveals the fact that the native pastoral tribes are now confined to the three drier communities. There is ample evidence, such as the existence of Masai place-names throughout the Kenya highlands, to show that these tribes formerly ranged far and wide. The pastoralists are a more war-like people, and therefore in the past they encroached upon the territory of the agricultural tribes, but in the higher-moisture areas concerned this could have no adverse effect upon the vegetation and the land. The establishment of European administration has reversed the process, so that the present tendency is for expansion down the scale of moisture conditions, by the incursion for agricultural occupation into the pastoral regions with marked damage to the vegetation and soil erosion.

In order to assess the problem of rehabilitating vast areas of degraded soil and vegetation and to appreciate the possibilities of improvement, the first requirement is a knowledge of the climatic and soil regions involved. This requirement is obviously essential to any plan of correct land utilization. In Kenya no provision for a comprehensive survey of this nature has yet been made, but in the course of work over a number of years concerned mainly with administrative problems, the classification and preliminary mapping of the major plant communities has been undertaken by the writer. The regions demarcated by each community may be assumed to represent similar environmental conditions, and although present knowledge does not permit of analysis of the complexes concerned, even in regard to the available meteorological data, the classification provides a basis for investigation of the reaction to management of the different vegetation types. It has already been pointed out that the effect of extension of utilization methods developed in a particular vegetation type to regions of different climatic conditions is in many cases only too apparent.

Six main regions of vegetation have been recognized in Kenya, occurring in some cases as several isolated masses, and extending into the adjoining territories. Roughly one quarter of the country to the south-west is occupied by relatively moist vegetation types situated on elevated land, while the remainder, with the exception of the more tropical coastal belt, supports semi-desert bush and scrub. The area of the country (excluding water surfaces) is 219,730 square miles and it extends to approximately 4.5° on either side of the equator.

The rainfall varies in a general way from extremely dry conditions in the north and east, where the rainfall is erratic and in the region of only 10 inches (25 cm.) per annum (in the neighbourhood of Lake Rudolf it is as low as 5 inches), to the relatively high moisture conditions of the Lake Victoria basin in the south-west with a rainfall of 60 to 80 inches (150-200 cm.). This general trend of the moisture conditions is interrupted by the highland area which is situated in the central and south-western portion of the country.

The elevated land mass lies mainly at altitudes of from 5,000 to 6,000 feet, and includes mountain peaks of considerably greater height, such as Mount Kenya (17,000 ft.). In comparison, the arid plains are situated in the main at approximately between 1,000 and 2,000 feet. The conditions of the highland region are characterized by relatively low temperatures and high rainfall over considerable parts of the area. In the portion of Kenya to the east of the Great Rift Valley, which cuts through the country roughly from north to south, the rain is derived mainly from the South-east and North-east monsoons, which blow from April to June and again in November, while the climate of the western portion is affected, in addition, by rain-bearing winds from Lake Victoria which result in precipitation during the months of July and August. At the higher altitudes and also in the coastal belt, mists are an important factor in the moisture conditions and they probably have considerable bearing on the types of vegetation which exist in these localities. Although moisture constitutes the chief limiting factor in the distribution of the major plant communities, rainfall figures alone are a very inadequate guide to the prevailing conditions. Evaporation, for which few data are available, is of extreme importance, particularly in the vast semi-arid region of the country.

It will be appreciated then that a very wide range of climate exists in Kenya. The greater part of the country to the north and east is arid and hot, towards the west there is a tendency for change to the moist, tropical conditions of the adjoining territory of Uganda. The highland area has a climate which may be described as sub-tropical, except for the short day-length connected with its geographical position on the equator. This great variation of climate naturally gives rise to clearly contrasted types of vegetation which, if they can be defined, provide a sure index of the ecological conditions in the various regions.

The six major plant communities which have been recognized are (in descending order of moisture conditions) as follows :—

Highland Grassland and Highland Forest.

Scattered Tree Grassland (Low Tree-High Grass).

Coastal High Grass—Bush.

Scattered Tree Grassland and Open Grassland (*Acacia-Themeda*).

Desert Grass—Bush (Dry Bush with Trees).

Desert Scrub.

These communities, together with others of less importance, are shown on a provisional map which accompanies this paper pp. 32-33.

ASPECTS OF CONSERVATION IN THE VARIOUS VEGETATION TYPES

Highland Grassland and Highland Forest. (FIG. 14).

This type which occurs in the highlands of Kenya is of limited extent. It is situated on isolated masses of elevated land, mainly between 6,500 and 9,000 feet altitude, with rainfall varying between 35 inches (in the drier, transitional fringe) and 90 inches per annum, supplemented by mountain mists. Both relatively low temperatures and high moisture limit the

distribution of the type. The vegetation consists of comparatively small areas of forest with extensive areas of undulating, open grassland.

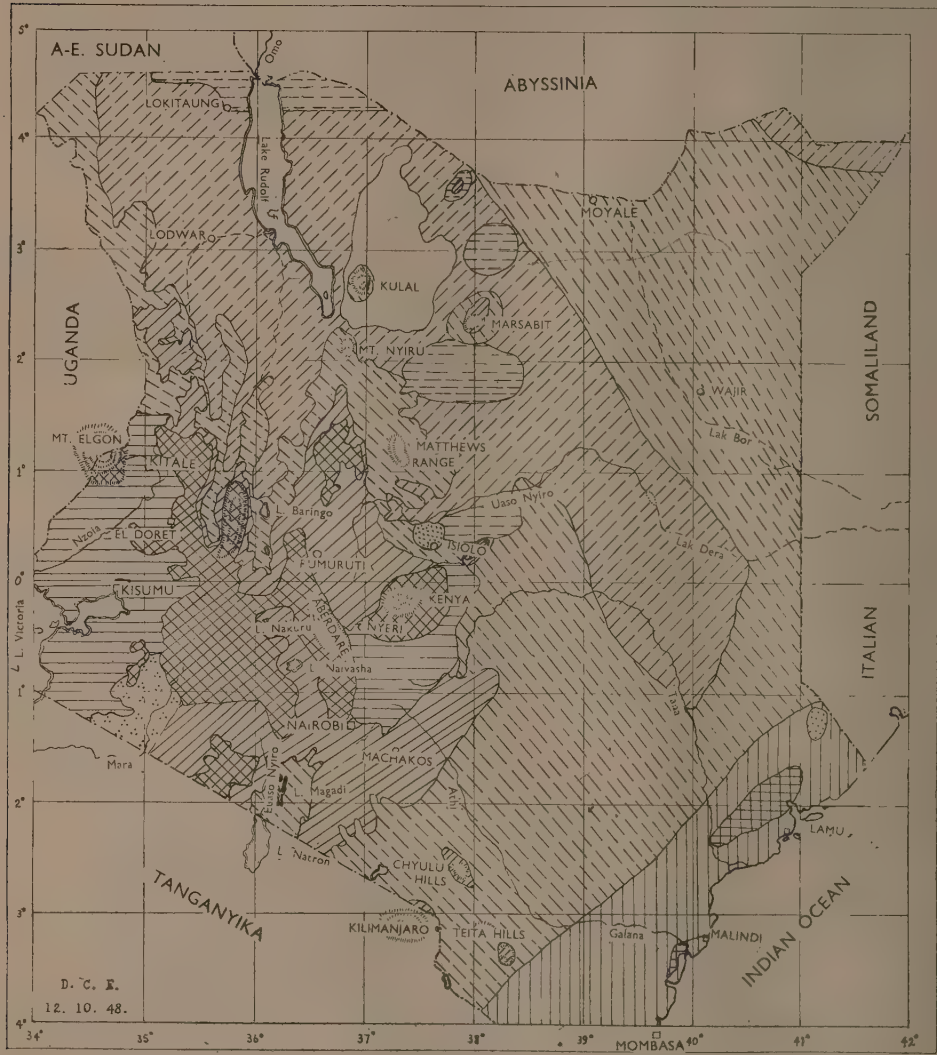
In general, a belt of bamboo (*Arundinaria alpina*) is found at the upper and moister fringe of this evergreen forest, extending to approximately 10,000 feet elevation, while at the lower and drier edge the forest consists largely of cedar (*Juniperus procera*) and olive (*Olea chrysophylla* and *O. hochstetteri*).

The forest falls into two main types related to moisture conditions ; (a) a high-moisture type under annual rainfall of from 55 to 90 inches, confined mainly to the eastern slopes of the mountain masses, and (b) a lower moisture type under rainfall of from 35 to 55 inches. The former is characterized by the absence of cedar and is largely dominated by *Ocotea usambarensis* (East African camphor) and *Podocarpus milanjanus*. The latter is composed chiefly of *Juniperus procera*, *Podocarpus milanjanus* (at higher altitudes), *P. gracilior*, *Olea chrysophylla* and *O. hochstetteri*.

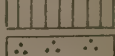
The rolling grasslands are chiefly dominated by *Themeda triandra* (red oat grass), which apparently constitutes a fire sub-climax, but wherever grazing is intensified to a degree just sufficient to prevent grass fires, a useless coarse-grass phase dominated by *Pennisetum schimperi* and *Eleusine jaegeri* takes possession of the land. In the main vegetational type (where rainfall is upwards of 40 inches per annum) intense concentration of animals and the accumulation of manure or clearance of the rough herbage by ploughing results in a close, stoloniferous sward of *Pennisetum clandestinum* (Kikuyu grass) associated with *Trifolium johnstonii* (Kenya clover), a highly productive sward which can be maintained under intensive grazing management. In the transitional belt, under lower moisture conditions, fringing this vegetation, Kikuyu grass herbage cannot be economically maintained, and as the coarse-grass phase advances, the choice of management lies between extensive, light utilization, employing fire to maintain the dominance of *Themeda*, and the substitution of the coarse phase by artificially established, temporary grass and other crops.

Many other grasses occur in this region and some of the more common ones in the Kikuyu grass area are *Andropogon chrysostachyus*, *A. pratensis*, *Exothea abyssinica*, *Digitaria abyssinica*, *Eragrostis lasiantha*, *Setaria sphacelata* and *Agrostis* spp., while in the transitional zone, in addition to the two main species of the coarse-grass phase already mentioned and several of the foregoing species, other large, tufted grasses such as *Pennisetum catabasis* and *Sporobolus filipes* are conspicuous in some areas.

As will be appreciated from the above outline of the grassland succession, correct development in this vegetation involves intensification of management in parts of the region, particularly where extensive holdings under European occupation, at present run largely on ranch lines, are concerned. Crop production in both European and native areas requires to be based upon alternate husbandry, so that the structure of the arable soil can be maintained by the use of temporary pasture leys. Such a means of safeguarding the soil is urgently required in portions of the area, as for instance the Kikuyu Reserve, where increasing population density cannot be supported by the old methods of shifting cultivation and the reduced



REFERENCE

Highland Grassland and Highland Forest.....	
Coastal Forest	
Scattered Tree Grassland (Low Tree-High Grass).....	
Coastal High Grass-Bush	
Grouped Tree Grassland.....	
Scattered Tree Grassland and Open Grassland (<i>Acacia-Themeda</i>).....	
Scattered Tree Grassland and Open Grassland (Other Types)	
Desert Grass—Bush (Dry Bush with Trees).....	
Desert Scrub.....	
Desert Grass and Desert Shrub.....	
Desert.....	

period of bush fallow is quite inadequate to maintain the soil. The position is aggravated by the fact that a great deal of this vegetation is situated in a region of numerous small valleys and steep slopes, the latter being ever more extensively cultivated by this agricultural tribe. An important factor which has accelerated deterioration in recent years is the adoption of cash-crop production by the inhabitants of the region on an extensive and rapidly increasing scale. This tax upon the land, in addition to the primitive requirements of food, is a development which is common to all the tribes occupying the agricultural areas, and is of course linked with the needs induced by civilization.

Scattered Tree Grassland (Low Tree-High Grass). (FIG. 15).

The community to which this name is given consists of grassland with herbage 5 to 8 feet in height, thickly scattered with small trees which are in the main 10 to 15 feet high. The appearance of the vegetation is often reminiscent of a cultivated orchard. Larger trees some 30 feet in height occur occasionally, and a characteristic feature of wide regions is the existence of isolated small areas of tall forest trees (50 to 90 feet) evidently resulting from exceptional ground water conditions.

Typically, the small trees are broad-leaved and deciduous with characteristic, fissured, corky bark. The most general dominant is *Combretum*, frequently *C. splendens*, while other characteristic trees are species of *Erythrina*, *Terminalia*, *Ficus*, *Faurea*, *Heeria*, *Bauhinia* and *Dombeya*. The grasses which contribute mainly to the "high grass" character of this vegetation are members of the genera *Hypparrhenia* and *Cymbopogon*, although the herbage is often complex and contains a considerable range of grasses. Some of the more common are *Themeda triandra* (dominant in localized areas), *Panicum maximum*, *Setaria sphacelata*, *Sporobolus indicus*, *Brachiaria brizantha*, *B. soluta*, *Chloris gayana*, *Setaria* spp., *Loudetia kagerensis*, *Digitaria* spp., *Beckeropsis unisetata*, *Paspalum scrobiculatum* var. *commersonii* and *Cynodon* spp.

The type is found roughly between altitudes of 3,000 and 6,000 feet and the annual rainfall is estimated to vary from one part of the region to another between 35 inches and 60 inches. This vegetation appears to be a seral phase leading to forest. The phase is maintained largely by the frequent passage of fire, in the absence of which factor thicket tends to replace the high grass between the scattered trees. The community covers an extensive region, occurring in two main masses, in the Lake Victoria basin to the west and to the south-east of Mount Kenya.

Under the relatively high rainfall conditions of the type, control of fire and correct intensive management of grazing are capable of inducing improved composition of the herbage and increased productiveness by the encouragement of finer grasses and stoloniferous species such as *Digitaria* and *Chloris gayana*. Extensive and advanced deterioration of the vegetation and soils has resulted from the crop-production practices in existence. In the part of the region towards Lake Victoria and also in much of the area to the south-east of Mount Kenya, a dense native agricultural population,

subsisting by means of shifting cultivation, has produced similar degradation to that mentioned in the case of the foregoing plant community where the Wakikuyu Tribe is chiefly concerned. In the areas of European occupation, such as the Trans Nzoia to the west of the Rift Valley, cash crops have been grown continuously in past years with no provision for soil recovery. It is by no means uncommon to encounter areas in which maize has been produced for 20 years in succession. The soils concerned are often of a light and somewhat sandy nature, and the deterioration caused differs only in degree from that of the densely populated native areas.

The possibilities of correcting the downward trend in this vegetation type are also similar to those described for the Highland Grassland. Where tillage for crops has not already occupied the land, the natural pasture can be maintained and improved by means of suitable intensive management. In the native agricultural regions there is urgent necessity for the introduction of the grass ley in place of the inadequate bush fallow, to recover and safeguard soil structure, while in the European areas the development of ley farming is less urgent only on account of the fact that the land is not densely occupied.

Coastal High Grass—Bush. (FIG. 16).

This vegetation consists typically of dense, high bush. The chief constituents are *Acacia* and *Commiphora*, but many other genera and species occur. Grass 6 to 8 feet high is plentiful and considerable areas of open grassland are frequently encountered. Some of the main constituents of the rank herbage are species of *Hypparrhenia*, *Digitaria*, *Setaria* and *Eragrostis*, while *Chloris myriostachya* extends from the drier community to the north into the open glades, practically until the coast is reached. In some areas the Baobab tree (*Adansonia digitata*) is a striking feature of the vegetation. In the immediate neighbourhood of the coast-line narrow belts of Doum palm (*Hyphaene thebaica*) alternate with open areas of high grass, and tall Mango trees resulting from ancient human occupation are often common. In somewhat drier portions of the community the vegetation consists of comparatively open woodland in which the main trees are *Acacia* and *Dobera*, 20 to 30 feet high, and in other localities a *Diospyros* species, 40 to 50 feet high, becomes prominent, while *Dobera* remains a frequent constituent. In these open woodland areas the herbage is not of the true high-grass character and it is frequently dominated by *Chloris myriostachya* and occasionally by a coarse *Sporobolus* species about 2 feet in height.

The existing areas of Coastal Forest are of limited extent, and they constitute a separate community the description of which is not considered necessary to the present discussion.

The climate which supports the main vegetational type is represented by rainfall of approximately 40 to 45 inches per annum and altitudes do not exceed 1,000 feet above sea level. The moisture conditions are, however, not truly represented by a consideration of the rainfall figures alone, since the presence of a coastal mist belt is indicated by the prevalence of lichen on the bushes and trees, often producing a uniform grey appearance in dormant periods, extending for a considerable distance inland from the coast.

The vegetation described occupies the relatively narrow belt of territory in the Kenya coastal region, giving place to a drier community slightly north of the Kenya frontier. The chief cause of soil deterioration and erosion is the employment of wasteful methods by native agricultural communities concentrated in certain portions of the region. Practically the whole of the area under consideration is infested by tsetse fly, and the possibility of utilizing cattle in conjunction with arable agriculture is seriously limited by this factor. Advance to the use of the pasture ley as a means of conserving the soil must, therefore, be preceded in large measure by steps for eradication of the fly. If this can be successfully accomplished, the way will be open, not only for the replacement of the present shifting cultivation by ley farming, but considerable areas at present uninhabited or thinly occupied might be opened to utilization, and so relieve the pressure of population elsewhere. In addition to the use of temporary pasture in the arable rotation, the reaction to management of the natural herbage in this vegetation type requires investigation, since little is yet known of its possibilities.

Scattered Tree Grassland and Open Grassland (Acacia-Themeda). (FIG. 17).

This community was formerly known as Acacia Tall Grass Savannah, but the above name was adopted in conformity with the views of the first East African Pasture Research Conference held in Nairobi in August, 1940.

The vegetation type is the most extensive in the highlands of Kenya and the characteristic condition is that of flat-topped *Acacia* trees widely scattered in an even cover of grass, 3 to 4 feet high. The trees are often 50 feet in height, but much of this grassland is scattered with small, thin *Acacia* plants only 6 to 8 feet high. The latter most frequently consist of *A. drepanolobium* with prominent ant-galls on the spines. Extensive open areas occur where *Acacia* is little in evidence and where it appears only as isolated plants or in small groups.

Some of the more common trees are *Acacia hebecladoides*, *A. seyal*, *A. senegal*, *A. stenocarpa* and *A. subulata*. Near water *A. xanthophloea* is very common and *A. campylacantha* is also present. Other genera occur occasionally, and in rocky situations large candelabra-like *Euphorbia* often present a striking appearance, also in such localities Aloes and other succulents are common. The main grass-dominant, *Themeda triandra*, appears to be associated with moderately high elevations in Kenya, and it does not assume importance below about 4,000 feet. This grass very generally dominates the tall, even cover of herbage in the community, although many other species occur, and these vary in importance from one locality to another. Legumes are relatively scarce in this herbage and they are chiefly represented by species of *Indigofera* and *Crotalaria*. Other important grasses are *Pennisetum mezianum*, *P. massaicum*, *Eragrostis* spp., *Hyparrhenia* spp., *Setaria* spp., *Digitaria* spp., *Bothriochloa insculpta*, *Cenchrus ciliaris* and occasionally *Chloris gayana* and *C. virgata*. Towards the drier margin of the type *Pennisetum stramineum* is dominant in localized areas, while *Cynodon plectostachyum*, which is widely distributed in favourable localities throughout the region, is mainly confined to a distinct association which occupies ancient lake beds.

Within the climatic zone, two main factors appear to exercise an important influence upon the chief constituents of this vegetation; these factors are impeded soil drainage and fire. The former tends to inhibit the growth of trees and appears to be responsible for the wide tracts of open grassland which are devoid of trees or where *Acacia* is thinly scattered in dwarf form, and where the main soil type is tropical black earth. The second factor (fire) is closely connected with the dominance of *Themeda* throughout the region, and experimental evidence indicates that the dominance of this grass is preserved by the frequent grass fires which occur in the dry season (Edwards, 1942). Fire also has a decided effect in retarding the advance of the tree and bush constituents. Although grass burning is a deeply rooted custom of the pastoral tribes which inhabit the main part of the region, it appears reasonable to suppose that the pyrophytic nature of the vegetation arises from natural causes. Such is the dry condition of the herbage in rainless periods, that fires probably occur independently of man's activities, and the evidence of recent volcanic activity suggests that it has been an important cause at no very remote period.

This distinct type of vegetation is situated in Kenya about the equator and here the range of altitude is approximately from 4,000 to 6,500 feet, while the rainfall, which is erratic, varies from 20 to 30 inches per annum, with droughts as a feature of the climate.

The whole extensive region of this plant community is adapted to light grazing management. Only at the fringe, where transition towards the moister adjoining communities is taking place, is crop production feasible, and even here it should be mainly confined to the storage of reserve fodder for animals. Extensive devastation of the vegetation causing reduced stream flow and soil deterioration, in some areas amounting to severe erosion, has taken place in portions of the region and these conditions are rapidly advancing. The cause is to be found in the extension of agricultural activities into ecological conditions which are incapable of supporting them. Instances of this maladjustment, enforced by pressure of population in the native communities concerned and even encouraged by misguided administration, are common, and they are exemplified by the expansion of the Wakamba from the Scattered Tree Grassland (Low Tree-High Grass) community in the neighbourhood of Machakos, and by the more recent advance of the Wakikuyu into the Masai country about Ngong from their home in the Highland Grassland and Highland Forest. Apart from the devastation caused by the invasion of agricultural tribes into this vegetational region, deterioration is relatively limited, and it is mainly associated with seasonal concentration of animals under pastoral conditions, resulting from scarcity of water supplies.

Desert Grass—Bush (Dry Bush with Trees). (FIG. 18).

This type constitutes the greater part of the semi-desert vegetation occupying at least two-third of the area of Kenya. It forms part of a vast community, extending to the north-east through the adjoining territory of Somalia almost to the Gulf of Aden. The vegetation consists of an assemblage of mostly deciduous bushes, 10 to 15 ft. in height, and usually branching from

near the ground with few well-defined trunks. Over considerable areas widely scattered trees, 20 to 30 feet high, project through the bush growth, and these are regarded as characteristic of the typical community. In the northern region of Kenya the bushes are spaced approximately from 12 to 30 feet apart. The ground vegetation between the bushes consists of scattered tufts of perennial grasses together with low shrubs, leaving much of the surface exposed.

The characteristic dominants of the bush throughout are *Commiphora* and *Acacia*, while the scattered taller trees which occur most frequently are *Delonix elata* and *Acacia spirocarpa*. Common amongst the low shrubs are species of *Sericocomopsis*, *Barleria*, *Aerva*, *Disperma* and *Indigofera*. In many areas, particularly towards the south, *Sansevieria*, grouped at the base of the bushes and occasionally forming dense stands, is a characteristic feature of the vegetation. *Acacia mellifera* is one of the most important bush constituents, and other common bushes and small trees are a twisted *Terminalia*, *Balanites* spp., *Boscia coriacea* and *Salvadora persica* ("Msuaki" Swa.), the last, chiefly on saline soil in the flood area of seasonal streams.

The grasses vary somewhat with the region concerned, but probably the most general dominant is *Chrysopogon aucheri* var. *quinqueplumis*. This species is important throughout the whole vast region of the vegetation type but it does not occupy the position of dominant in all areas; for instance, far to the north of the formation in British Somaliland where, although it remains of importance, two large tuft-grasses, *Aristida kelleri* and *A. papposa* are the chief dominants, and towards the coastal region of Kenya to the south, *Chloris myriostachya* is the most important grass. This last species is absent from the driest parts of the community and its distribution appears to be influenced more by temperature than by low moisture conditions. Other important grasses are *Cenchrus ciliaris*, *Enteropogon macrostachyum* and species of the genera *Aristida*, *Sporobolus*, *Tetrapogon*, *Latipes* and *Enneapogon*, together with *Digitaria* in localized areas.

For the greater part of the year the Desert Grass-Bush is leafless and in a drought-dormant condition, with the tufted grasses dry and brittle. The whole region is subject to low and extremely erratic rainfall, estimated to vary from 10 to 15 inches per year as an average, but where droughts of several years' duration may occur. A feature of the climate is a desiccating wind which blows during the protracted dry seasons. In Kenya, the elevation of the main region is approximately 2,000 feet. It is noteworthy that the low moisture conditions permit of few permanent streams and that drainage chiefly takes the form of water courses which are dry except at short periods immediately following rain. No permanent stream exists north and north-east of the Juba River, between this and the coast of the Gulf of Aden.

In addition to erosion by water, wind erosion assumes importance in this region. In all areas the transport of soil particles by wind can be readily discerned, and it appears that even where no deterioration of the vegetation has taken place, at points far removed from water, the natural cover is insufficient to prevent a constant tendency to movement at the soil surface. This tendency is accentuated towards the north of the community, where in British Somaliland and to the south of that territory, sand drift is of major

importance, particularly in connexion with the marked effect upon the vegetation caused by the Somali pastoralists. In this northern area certain plants appear to have assumed a habit designed to resist sand-bearing winds. Thus the widely-distributed grass, *Chrysopogon aucheri*, is found in the form of tight cushion-like tufts, quite distinct from the open tufts of the grass in the southern portion of the community in Kenya. Adaptation in the same direction is found in certain *Acacia* species, protruding from small sand dunes and with prostrate branches clasping the surface.

It will be appreciated that the low moisture conditions which support this vegetation result in a high degree of instability, and little undue concentration of animals and population is sufficient to tip the balance towards deterioration. Devastation is mainly connected with concentration resulting from scarcity and poor distribution of water supplies, which are chiefly in the form of wells. It is often possible to trace the effect upon the vegetation of concentration at a well for a radius of some 15 miles. The remedy lies in the improvement of watering facilities and control of the seasonal migrations of the native tribes. This latter requirement involves a study of the causes of migration and of the claims to ownership of the existing water supplies and grazing grounds. The investigation can therefore be undertaken only in close collaboration with the Administration and with considerable assistance from that source. A factor of major importance, which is also primarily a political problem, is the steady migration of the Somali tribes from their place of origin on the Gulf of Aden southwards, until the invasion of eastern and northern Kenya is now in progress. These people, who have resulted from an admixture of Arab blood, have caused widespread devastation in British Somaliland at the source of the migration, largely through inadequate administrative control, and their spread to the south threatens to increase the difficulty of solving the conservation problem. Administration of the Somali peoples as a single block or at least with much closer co-ordination than has hitherto been found possible on an inter-territorial and international basis, would appear to be a prerequisite to this aspect of conserving the vegetation. In addition to the above more general forms of deterioration in this plant community, severe destruction and soil erosion is caused at a number of points by the incursion of agricultural tribes at the fringe, as in the case of the previously described community. Thus to the south, in the region of Kitui in Kenya, the extension of millet cultivation by the Wakamba from the neighbouring community has been responsible for considerable devastation in recent years.

Desert Scrub. (FIG. 19).

The vegetation consists of low bushes and stunted trees forming a thin cover in which the bare ground is always conspicuous. The bushes are from 4 to 10 feet in height and they are spaced about 15 to 24 feet apart. The leaves are mainly small and inconspicuous, and the whole community is in a drought-dormant condition and leafless except for brief periods following rain. The grasses and other herbs are ephemeral, appearing after rain, and perennial grasses are insignificant. The sparse ground vegetation consists mainly of small shrubs. Viewed from a distance the dominating colour of

the landscape in this vegetation is that of the bare ground showing through the thin cover of plants

The two chief dominants of the scrub, *Commiphora* and *Acacia*, are the same as those of the Desert Grass-Bush and many other plants are common to the two communities. The Desert Scrub might, in fact, be regarded as a dry form of the Desert Grass-Bush vegetation except that the taller trees described for the latter type are not found in the Desert Scrub, and the virtual absence of perennial grass is of practical importance.

In extent, the area covered by this vegetation in Kenya is second only to that of the Desert Grass-Bush. The moisture conditions are distinctly lower, the average annual rainfall probably not exceeding 10 inches over the main area and being only about 5 inches in some parts, such as the neighbourhood of Lake Rudolf.

The type of deterioration and the conservation problem are similar to that described for the foregoing Desert Grass-Bush community. Degradation has resulted mainly from undue concentration at the scant water supplies. There is, however, an aspect of management which offers scope for improvement. The virtual absence of perennial grass in the Desert Scrub limits grazing by cattle to the brief periods following rain when ephemeral herbage is available. For the remainder of the year the vegetation is capable of supporting only browsing animals such as camels and goats. Much damage is caused when sections of the tribes linger at water supplies after the main seasonal migration out of the region has taken place. Improvement could be attained by exercising control over the migrations in order to avoid this cause of localized deterioration of the vegetation and soils, and at the same time to ensure utilization of the two semi-desert plant communities on a strictly seasonal basis, thereby providing for protection of the Desert Grass-Bush during the growing seasons. Control of grazing on a simple rotational basis within each community would be a later necessary step.

One spectacular instance of deterioration from drifting sand occurs in the Desert Scrub vegetation of Kenya. This is found both to the east and the west of the central portion of Lake Rudolf, where the sand is moving steadily towards the west destroying the vegetation, and being afterwards occupied by a sparse cover of shrubs. The source of the drifting sand is an extensive lake bed (now known as the Chalbi Desert) which has evidently dried out in recent (though prehistoric) times, and the shores of Lake Rudolf itself which is subject to variations in the water level. Under the extremely low moisture conditions which prevail, this particular case of deterioration appears to be beyond control.

CONSERVATION MEASURES

It is held that any plan for conservation of the natural resources of a country, must, to be effective, be based essentially upon an ecological classification of the territory concerned. Such a classification is required to indicate the possibilities of improvement as well as the directions in which it should be attempted. It will be apparent from the foregoing account of the causes of biotic degradation in the various ecological regions that no amount of effort expended in the present methods of soil conservation can be expected to induce recovery, unless readjustment of the forms of human

occupation to the natural conditions of the areas concerned can first be attained. Where, for instance, a native population dependent upon crop production has extended its activities from a region of relatively high moisture conditions into a plant community which is capable of supporting, without marked deterioration, only pastoral occupation, obviously either the population must be removed or it must be induced to change its mode of life. The latter is, of course, a remote possibility and one which cannot be seriously considered. In the past, too little attention has been paid to the ecological aspect of conservation, no serious attempt has been made to classify the natural conditions of the various regions and one of the main, if not the chief cause of deterioration in East Africa has consequently been to a large extent ignored. The suggestion may here be made that the survey project envisaged above appears to lend itself to organization upon an international basis in Africa.

More detailed survey knowledge than is at present available is required in areas where the problem of soil erosion is already acute, and in presenting the foregoing broad classification of the major plant communities, the aim has been to give only a sufficient description of the vegetation to indicate that classification and clear definition of the ecological regions are possible from it. Surveys of soil and of the other factors concerned are also desirable, but it is suggested that the natural vegetation affords the best available index of conditions in the regions demarcated by the plant communities. Given this classification, the research which is urgently needed into the application of conservation methods to local conditions should be conducted on a regional basis, as should also the other major projects of agricultural research.

Realization of the necessity for conservation measures has certainly grown in recent years amongst Europeans and, it is believed, to some extent amongst Africans. Also, research of basic importance to the required improvement in agricultural methods has advanced, and a Soil Conservation Service has been in operation in Kenya for some years. It is perhaps natural that the first step should be an attempt to set the house in order in the areas of European farming and much is being done in this direction, even to the extent of legal compulsion, but the urgent problem of conservation exists in regions of native occupation and it is here that the real menace to the future of the country has to be faced.

Study of the natural grasslands associated with the main types of vegetation, with a view to devising methods of management capable of preserving a balance between utilization and deterioration, is obviously one of the most important requirements. So far, only a limited amount of work in this direction has been possible in the absence of regional research stations and the necessary trained staff, although the plan for such a research scheme was accepted in 1940 by the East African Pasture Research Conference (East Africa 1940), already mentioned. In Kenya such work has been confined mainly to management problems of the Highland Grassland (Edwards, 1940), while Staples' experiments in the Grass-Bush community of the Mpwapwa region of Tanganyika are of considerable significance (1945, 1942).

The provision of pasture species suited to the establishment of temporary pastures under the conditions of the agricultural areas, both native and European, is the first step towards the essential change-over to improved methods in these areas. Recent evidence indicates that deterioration of physical structure in the soil is of critical importance under East African conditions (Martin, 1944; Edwards, 1945), and the extreme importance of the pasture ley in recovering and maintaining structure is now realized. Considerable attention has been given to this aspect of the work, and, as the result of experiments mainly upon indigenous material, pasture plants which are capable of meeting the requirements of practically all the agricultural areas of Kenya are now available. The most important of the grasses already in use are a local ecotype of *Chloris gayana* (Rhodes grass) (Edwards, 1943), *Melinis minutiflora* (Molasses grass) and *Bromus marginatus*. A sufficient degree of persistence under intensive management and good seeding properties are two of the qualities which have been sought, and it has been by no means easy to find indigenous grasses in which these qualities are combined. A considerable number of promising indigenous species is under experiment, and the numerous ecotypes or geographical strains of those already in use evidently offer a fruitful field for study. A rapid, though limited, development of ley farming has taken place in the European areas of Kenya in the past few years, in part as the result of increased crop production during the war period and the consequent existence of surplus arable land, but also from a growing realization of the necessity for soil conservation measures. Thanks to this development, a considerable and increasing demand for seed of the above grasses has arisen and seed production on a relatively large scale is in progress.

Despite the progress which can be claimed in certain areas and the unremitting effort which has been directed to checking the rapid deterioration which is taking place in the densely populated native reserves, it is plainly evident that the rate of improvement is too slow, and that deterioration is steadily gaining ground. Apart from the necessity of taking any possible steps to adjust the forms of utilization to the regions capable of supporting them and to avoid the further extension of incorrect land use, it is suggested that the stage has already been reached when the problem with which we are faced is not primarily that of determining the conservation methods to be used, but that of how to apply the knowledge which we already possess. The question arises as to whether these methods can in fact be applied with sufficient rapidity to the areas of African occupation, and upon the answer to this question depends, in large measure, the future of East Africa.

SUMMARY

Over considerable areas of East Africa the development of the vegetation is influenced by man, but marked change resulting in extensive soil degeneration is chiefly of recent origin. Under the changed conditions brought about by increased native population and the growth of wants associated with the advance of civilization, the existing primitive forms of utilization are no longer capable of preserving a balance which avoids deterioration.

Destruction of the vegetal cover and consequent soil degradation arise from two main causes ; (a) the extension of forms of human occupation from the regions in which they have developed to regions of ecological conditions incapable of supporting these forms of occupation, and (b) the development of agricultural practices which result in undue exposure of the soil surface, both within the former habitat and in the areas to which migration has taken place.

European development in East Africa during the past 50 years has resulted in a large measure of control over human and animal diseases, the cessation of tribal warfare and the intensification of agriculture through increased population and the growth of wants connected with civilization in the more productive regions of native occupation. Consequently, there is a tendency on the part of the agricultural and semi-agricultural tribes to extend their activities into vegetational regions incapable of supporting them, while within the densely populated native agricultural areas land use based upon shifting cultivation is causing severe deterioration of the vegetation and soils.

Planned utilization must be based upon regional classification of the ecological conditions, in order that all possible steps may be taken to eliminate land use which causes destruction of the vegetation and soil erosion. Unless readjustment of the forms of human occupation to the natural conditions of the areas concerned can be attained, effort expended in the present methods of soil conservation cannot be expected to induce recovery.

The natural plant communities are indicated as the best available index of the ecological regions and the six major communities of Kenya are briefly described. The causes of deterioration in each of these vegetational regions and the possibilities of improvement are discussed, with particular reference to the extension of crop production from the higher moisture vegetation types to drier regions capable of supporting only pastoral occupation. Ecological survey in Africa on an international basis is suggested.

A necessity of planned development is the establishment of agricultural research stations based upon the ecological regions as indicated by the major plant communities. This is of special importance in regard to study of the natural grassland types, in order to devise methods of management designed to avoid further deterioration.

The first step towards checking deterioration in the densely populated native agricultural areas is the introduction of the temporary grass ley in place of the bush-fallow of the primitive shifting cultivation system, which is no longer adequate to maintain the soil, particularly in regard to its physical properties. Grasses suited to the requirements of the main regions of Kenya are available as the result of work chiefly upon the indigenous flora. The use of these grasses is rapidly gaining ground in the areas of European settlement, but the urgent problem in regard to this and the other aspects of conservation exists in the native reserves, and the crux of the whole matter is the possibility of applying the knowledge already available to these areas where devastation is rapidly advancing.



FIG. 14.—Highland Grassland and Highland Forest, showing patchy distribution of Forest, Timbora. D. C. Edwards



FIG. 15.—Scattered Tree (Low Tree/High Grass), north of Kitale. D. C. Edwards



FIG. 16.—Coastal Vegetation near Kwale.

J.A. Allan.



FIG. 17. Scattered Tree Grassland (*Acacia Themedia*) south-east of Rumuruti.

D. C. Edwards

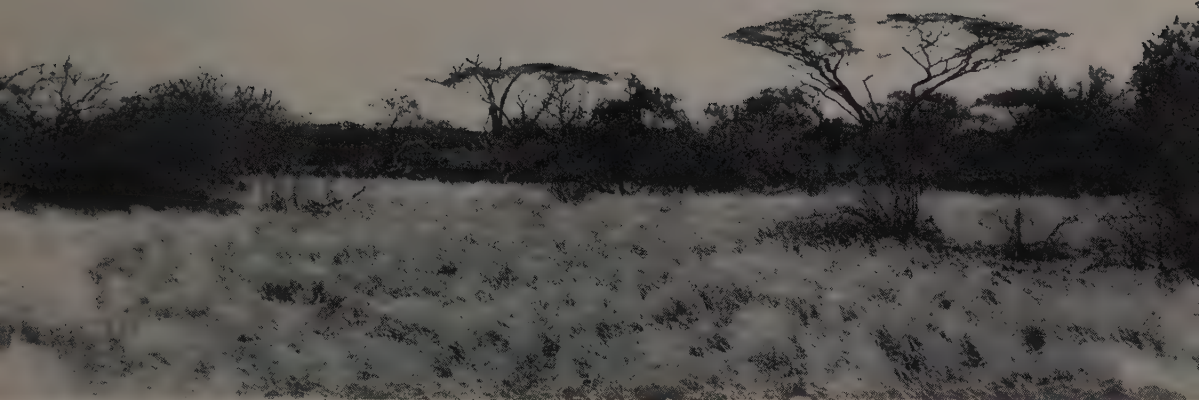


FIG. 18.—Desert Grass/Bush (Dry Bush with Trees) east of Tana River.

D. C. Edwards.



FIG. 19.—Desert Scrub showing *Commiphora* and *Acacia*, north-west of Isiolo.

D. C. Edwards.



FIG. 20.—The effect of African agricultural occupation in a marginal area, Ukamba.

D. C. Edwards.



FIG. 21.—Sheet erosion, Ukamba.

D. C. Edwards.

BIBLIOGRAPHY.

- EAST AFRICA. 1940. Report of the First East African Pasture Research Conference, Nairobi. pp. 54 (Mimeographed).
- EDWARDS, D. C. 1940. The reaction of Kikuyu-grass (*Pennisetum clandestinum*) herbage to management. *Emp. J. exp. Agric.* Vol. 8. pp. 101-110.
- EDWARDS, D. C. 1942. Grass-burning. *Emp. J. exp. Agric.* Vol. 10. pp. 219-231.
- EDWARDS, D. C. 1943. The Nzoia type of Rhodes grass (*Chloris gayana*) for temporary leys. *E. Afr. Agric. J.* Vol. 9. pp. 62-68.
- EDWARDS, D. C. 1945. (See) East Africa, Department of Agriculture Annual Report, Kenya. pp. 100-107.
- MARTIN, W. S. 1944. Grass covers in their relation to soil structure. *Emp. J. exp. Agric.* Vol. 12. pp. 21-32.
- STAPLES, R. R. 1945. Bush control and deferred grazing as measures to improve pastures, Part I. *E. Afr. Agric. J.* Vol. 10. pp. 217-222.
- STAPLES, R. R. 1945. Bush control and deferred grazing as measures to improve pastures, Part II. *E. Afr. Agric. J.* Vol. 11. pp. 43-46.
- STAPLES, R. R., HORNBY, H. E., and HORNBY, R. M. 1942. A study of the comparative effects of goats and cattle on a mixed grass-bush pasture. *E. Afr. Agric. J.* Vol. 8. pp. 62-70.

III. CONSERVATION OF VEGETATION IN TANGANYIKA TERRITORY

BY

H. J. VAN RENSBURG

CIVILIZATION is rapidly stamping its indelible mark on East Africa. Development during the past decade has been much quicker than during the previous 70 years, since the time when Livingstone and Stanley marched through "Darkest Africa." The days of the slave trade have almost been forgotten. The desperate struggle for existence on a day to day basis is gradually being altered and land exploitation has almost become a natural feature under existing primitive conditions. A tree cannot be tolerated if it harbours birds which may damage a crop. Vegetation along valley bottoms or even in deep erodible gullies will not be spared if such places with a greater silt accumulation and a higher moisture content can produce grain, even if it is only for a very short period. A certain natural balance was maintained under the primitive conditions which existed in the past, and readjustments were brought about by periodic outbreaks of epidemics amongst the people and by devastating cattle diseases. Apart from local outbreaks of diseases the 1896 rinderpest onslaught decimated the cattle population from one end of the continent to the other.

The pendulum is shifting position ; the absence of suitable vegetation cover is becoming a major problem and periodic shortage of food is a great limiting factor. Diseases of cattle are being controlled better but more serious losses are occurring due to shortage of water supplies and inadequate grazing during periods of drought. Even those animals infected by the much-dreaded tsetse fly can now be successfully cured. There is no doubt that the maintenance, improvement and correct use of the vegetation cover is a most important aspect of the solution of this difficult problem. Much effort has been made to enlighten the people and there have been great improvements, but even to-day there are still severe local food shortages and in some respects the position seems to be deteriorating. The pattern of shifting cultivation is assuming an entirely different nature and farming has changed from primitive subsistence to exploitation, on a primitive but destructive basis. Under the old system there was a certain degree of recovery under natural conditions but to-day this is no longer possible unless improved farming methods are used and unless a suitable vegetation cover is restored, maintained and utilized to the best advantage.

The people of the world are becoming soil conscious. Land-use planning on a tremendous scale is now taking shape in different countries. The United States of America has taken the lead and is pushing ahead with vast projects and large development programmes. These are based on

planning for maximum production from the land, while at the same time it is being preserved in a productive state and improved by modern methods. No country can afford to lag behind in this important trend of development. Regional planning on an ecological basis is a first essential step in production planning. Soil types, vegetation, climate and environment are the main factors which influence any production scheme.

A brief outline of the main climatic regions is given below. Rainfall seems to be the most important single factor influencing plant growth. Topography is important as it greatly affects precipitation. Soil types play a very distinct role though in the absence of sufficient moisture they seem to be of minor importance.

FOREST AND EVERGREEN BUSH

In some of the coastal and mountain areas with heavy precipitation, rain forest and evergreen bush formations have developed under tropical and sub-tropical conditions. With sound methods of utilization these forests can yield valuable crops of timber, while the land remains productive and unspoilt. The effects of wasteful farming in such areas are only too well-known. Ruthless deforestation, by fire, axe and hoe, in mountain areas in the Southern Highlands of Tanganyika has left its mark, and the cultivation of annual crops on some of the steep mountain slopes is causing inconceivable wastage.

Warnings have come from other parts of this continent, notably from South Africa, where the occurrence of dangerous and uncontrolled devastating fires and acute water shortages have become the subjects of common headlines in the daily papers. The water shortage in Cape Town has become very critical during recent years due to the destruction of natural vegetation on the mountains and to lack of conservation methods in farming practices. These effects have been greatly intensified by periodic severe local droughts. Many other towns in the Union have suffered the same ordeal. Along the Soutpansberg and Haenertsberg mountains in the Northern Transvaal, numerous streams, which were formerly perennial rivers and springs, have dried up entirely. Long-established irrigation furrows have been abandoned due to lack of water. Citrus and other fruit trees, in beautifully laid out orchards, have died off, and a number of farms along the Shamrock Valley, near Tsaneen, have been closed down. Water supplies also seemed to have suffered greatly due to the planting of quick-growing Eucalyptus trees in the catchment areas and around springs. These trees, growing outside their natural habitat, seem to consume more water than could be made up by the rainfall.

On the Westfalia Estate, near Duivelskoof, in the Northern Transvaal, springs which have dried up due to the planting of Eucalyptus and to uncontrolled cultivation on the slopes have been again restored, and considerably increased over a period of about 8 years after removal of the trees in their vicinity. In parts of Zululand, Eucalyptus trees have been established with great success to dry up malarial swamps.

The protection of catchment areas is a subject that has been very widely discussed during recent years and America has voted large sums of

money for this purpose. To Southern Africa this is a problem of immense importance and the authorities in East Africa are endeavouring to extend the forest reserves.

Conditions which would support such rain forests and evergreen bush formations in Tanganyika exist in the following regions, most of which are situated above 5,000 feet and have a rainfall of 50 to 100 inches per annum.

Southern Highlands—Southern and Eastern Provinces.

Protection is essential for the entire escarpment, a vast area along the Highland block together with a large sweep of country including Dabaga, Mufindi, Lupembe, Njombe, continuing along the Livingstone mountains to Lake Nyasa, then North West to Tukuyu, Mbeya, Chunya and further on to the Sumbawanga Highlands near Lake Tanganyika in the Western Province. In addition to this vast though broken block of possibly more than 10,000 square miles there are the isolated masses of the Mahenge Massif, the Uluguru, Ukaguru and Nguru mountains near Morogoro and the Usambara and Pare mountains in the Tanga province.

Northern and Lake Provinces.

There is a very large area in the Mbulu Highlands in the Northern Province, including Oldeani and the 'Ngoro 'Ngoro crater. Apart from these there are many individual mountain blocks and extinct volcanoes such as Kilimanjaro, Meru, Essimigor, Ufiomi, Hanang and others. In the North Mara district of the Lake Province are also areas of considerable size. There are extensive areas of similar nature in Kenya and Uganda. In most parts these mountain forest areas have suffered from denudation, and much damage has been caused by the growing of annual crops. Valuable economic crops such as tea, pyrethrum and quinine are cultivated in several areas, but the extent to which these can be justly exploited for agricultural purposes is limited. For the greater part the areas should remain under forest or other suitable woodland.

GRASSLAND AND THICKET FORMATIONS

In the semi-arid areas the problem of protection of vegetation is quite different. Whereas in the high-rainfall regions it seems essential to encourage the development of climax vegetation, in medium rainfall areas or under more arid conditions it seems better to keep the plant growth at an intermediate level in the succession. Under natural conditions grass growth is maintained by periodic fires which keep the woody vegetation in check. This generally results in a parkland formation with open woodland and consisting of species with thick corky bark which are resistant to fire, or in open grassland with scattered clumps of bush and trees generally occurring around termitaria, antbear holes, rock outcrops, along fences and in other places which are protected from fire, or where seeds may be readily dropped by birds or other animals and then germinate under such comparatively favourable and protected conditions. The grasses which thrive best under these conditions are fire-resistant species, generally consisting of erect-

growing tall bunch types, such as *Hyparrhenia hirta*, *H. dissoluta*, *Andropogon schirensis*, *Themeda triandra* and *Loudetia simplex*.

When fires and grazing are prevented these grasses soon lose vigour because they have to compete with an increase of herbaceous plants and shrubs, the growth of which is no longer checked by burning. Succession development then proceeds until eventually a bush association is formed from which the grasses are practically entirely excluded.

With heavy uncontrolled grazing the successional trend is similar, except that erosion is generally more severe due to the destruction of the grass cover and the formation of cattle tracks which often erode and form deep gullies. The most notable features under such conditions are that woody plants rapidly increase and the formation of bush thicket is accomplished within a relatively short period, due to the exclusion of fire and as the result of the removal of grass by grazing.

Moderate grazing and mowing treatments result in a change of the species and appearance of the herbage but do not alter the entire formation as in the case of the treatments already described. The change would be more in the form of:—

- (a) thickening of the basal cover due to more light being available after removal of the tall erect growth ;
- (b) an increase in prostrate or running grasses and small bunch species, also due in part to the elimination of competition for light and to the exclusion of frequent and severe burning, which is detrimental to the runners of recumbent species.

These grassland/thicket areas are extensive and generally fall within the 18 to 26 inch rainfall areas. The woody vegetation is dominantly xerophytic, many species bearing thorns and spines. They are mainly represented by a large number of species of genera such as *Acacia*, *Commiphora*, *Grewia* and *Dichrostachys*.

The soil types in this formation vary considerably, a large proportion consisting of reddish and heavy grey loams and clay, and light to medium red sandy loams are not uncommon. In places where conditions are more favourable, for example, along stream beds, this deciduous vegetation gives way to sclerophyllous evergreen woodland or riverine bush, which, although it does not as a rule grow very tall, differs from the xerophytic thorny deciduous thicket formation in density, general appearance and growth.

These areas seem to be well suited for ranching and for mixed-farming systems which would enhance the quality of the pasture and further supplement the animal food supplies. Maize is grown in areas where the moisture conditions are relatively favourable though crops often fail due to prolonged periods of drought. Bulrush millet is extensively planted on slopes while Sorghum is grown on the bottom lands. Groundnuts are grown on a considerable scale under native conditions in the Central Province of Tanganyika and it is in this area that the colossal Groundnut Scheme project was commenced in 1947.

In the past these regions have suffered more from erosion due to poor farming than the rest of the Territory and in some cases entire districts have

been devastated, Kondoa Irangi being a striking example. Furthermore, these areas will continue to suffer and erosion will continue at an accelerated pace while tribal farming holds sway with all its superstitious customs and ignorance. Water conservation and other measures of conservation farming are essential if the desired improvements are to be brought about. The indigenous vegetation should be used to the best advantage in suitable farming systems. Plant succession has to be kept at what we may describe as an intermediate phase in the plant succession. Entire protection is not essential, or may not even be desirable, as in this case it does not play an important role in the conservation of water supplies as it does under rain forest conditions. However, a considerable amount of moisture can be conserved, and serious erosion can be prevented by maintaining a protective grass cover, and by tie-ridging cultivated land in order to prevent excessive run-off.

Staples (1933) found that, under the conditions prevailing at Mpwapwa in the Central Province of Tanganyika with an average rainfall of 26 inches per annum, the greatest penetration of moisture occurred on plots covered by grass or on those thoroughly cultivated, and that a high soil moisture content under these conditions was maintained for a much longer period than under deciduous thicket, which was apparently due to the rapid transpiration rate of the bushes. Furthermore, the run-off on grassed plots was reduced to less than 2 per cent of the rainfall as compared with over 50 per cent on bare uncultivated land. More than 59 tons of soil per acre per annum were lost from the bare uncultivated plot, while the loss on a grassed plot was nil.

BRACHYSTEGIA—ISOBERLINIA DECIDUOUS WOODLAND (MIOMBO)

This is by far the most extensive vegetation type in Tanganyika, and extends over most of Northern Rhodesia and into Southern Rhodesia, probably covering more than 500,000 square miles. It consists mainly of a large number of species of *Brachystegia*, *Isoberlinia globiflora* and *Combretum* spp. Most of it is infested by tsetse fly, and grazing extends only over a few limited settled areas. For the most part the soils are sandy and poor along the slopes, while lower down they fan out into vast grass-covered seasonal swamps where the soil generally consists of black heavy clay. Fires sweep through these areas annually or periodically and the grasses consist mainly of a number of species of *Hyparrhenia*, *Andropogon* and *Loudetia*. In the lower lying, periodically swamped (mbuga) areas, grass growth is generally very dense and trees are often absent or very stunted as a result of swamping and very fierce fires.

The rainfall is considerably higher than in the deciduous thicket formation, and varies between 30 and 40 inches per annum, falling between November and May. Maize is regarded as the staple crop in these areas but on the whole crops are very poor due to soil poverty and periodic droughts. Sorghum is planted in the heavier and generally darker-coloured soils in the temporarily-swamped areas, while a certain amount of bulrush millet is also grown.

It is in this vegetation type that the Groundnut Scheme Organization

contemplates the vast extension of activities in the Western Province, and also under rather similar conditions in the Southern Province of Tanganyika. On the whole this type of country consists of a fairly characteristic and homogeneous open woodland with trees about 40 or more feet high, and a grass growth underneath which varies in density depending upon soil conditions, moisture, and the thickness of woody growth. Under relatively high rainfall conditions and along the coastal belt, growth is luxuriant while under less favourable conditions it is rather stunted. Useful timber trees such as *Pterocarpus angolensis* (Mninga) occur abundantly.

The occurrence of tsetse fly throughout most of these areas obscures the problems connected with the conservation of vegetation, with the result that indiscriminate clearing methods have been resorted to, often with disastrous results. Thanks to the tsetse fly, this destruction has never been extensive, and under the fairly favourable rainfall conditions reasonable recovery is generally possible. Furthermore, these soils are more sandy than those in the deciduous thicket areas, and consequently are not so prone to deep gully erosion. Due to the occurrence of tsetse fly, large herds of cattle, which often cause serious destruction of vegetation in other parts, are absent.

CONCLUSIONS

One of the principal problems in East Africa at present is how to change from a system of primitive exploitative farming to sound farming whereby local resources can be utilized to the best advantage. We require thorough planning for the future on a basis that will allow for conservation.

Many of our development plans are based on the idea that improvement has to continue along lines which the African can follow ; this means that progress is necessarily slow, but at the same time there are various questions we have to ask ourselves :

- (a) to what extent can world conditions tolerate this concept in view of world economic development and competition for markets which exist to-day ? and
- (b) to what extent can primitive and exploitative methods of farming be allowed in view of the increased rate of deterioration on the land producing extraordinary low yields in times of world-wide shortages ?

In some parts of Tanganyika considerable improvements have been brought about by establishing large grazing reserves in which grazing is controlled, but these areas are totally inadequate in relation to the size of the problem. There is insufficient check on stock numbers and their movements. While some areas are closed to recuperate, others continue to erode at an accelerated pace. The solution to the problem on a practical basis, taking into consideration the various social aspects of tribal life, present many difficulties. The gap across which advancement is to take place is enormous and the time limit for bridging it is limited, and is becoming more and more restricted. In most areas native farming is carried out on a most primitive scale. Planned systems of improved farming on an individual or small community basis, with adequate provision of water supplies, bush

eradication, paddocking and general farming management are still very much in their embryonic stages. Under conditions of organized farming the provision of adequate water supplies, supplementary dry-season feeding, and paddocking to facilitate grazing management, are taken for granted. In East Africa, where conditions are still very primitive, we set ourselves the task of grazing management where hardly any of these improvements exist, and where they cannot easily be introduced.

The problem with all its different facets is very closely linked up with wise and efficient use of the soil and vegetation. We are living in the machine age and are experiencing the inception of schemes where management and an enormous capital expenditure of money is voted for work on the land in order to produce food.

BIBLIOGRAPHY

- GILLMAN, C. 1940. Water Consultants' report No. 6. A reconnaissance survey of the hydrology of Tanganyika Territory in its geographical settings. Government Printer. Dar-es-Salaam.
- JACKS, G. V., and WHYTE, R. O. 1939. The rape of the earth. Faber and Faber, London. pp. 313.
- RENSBURG, H. J. van. 1947. The role of pasture development in soil conservation, Tanganyika Territory. *E. Afr. agric. J.* Vol. 7. p. 48.
- STAPLES, R. R. 1933. A run-off and soil-erosion experiment. Part I. Annual Report of the Dept. of Vet. Sci. and Animal Husbandry, Tanganyika Territory. pp. 95-103.
- STAPLES, R. R. 1935. A run-off and soil-erosion experiment. Part II. Annual Report of the Dept. of Vet. Sci. and Animal Husbandry. Tanganyika Territory. pp. 134-141.



FIG. 23.—Mpwapwa. A grazing field developed after clearing dense deciduous thicket. The ideal pasture appears to be grassland with scattered trees.

FIG. 22.—Mpwapwa. Thicket vegetation cleared, but some large trees left in paddocks and along river banks. Pastures mainly star grass (*Cynodon plectostachyum*).

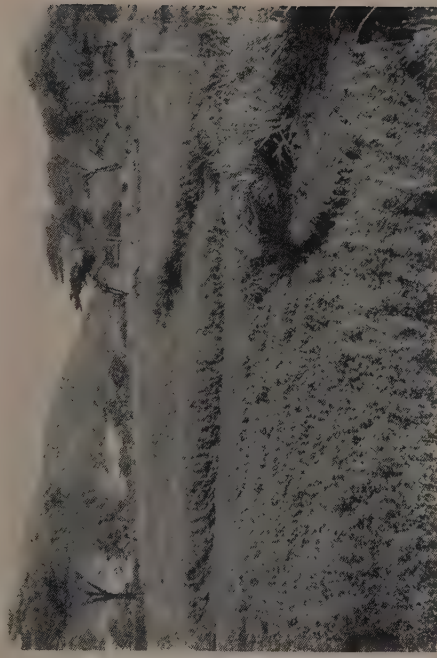


FIG. 25. Mpwapwa. Cultivation of lucerne and *Sesaria splendida* under irrigation for feeding dairy stock.

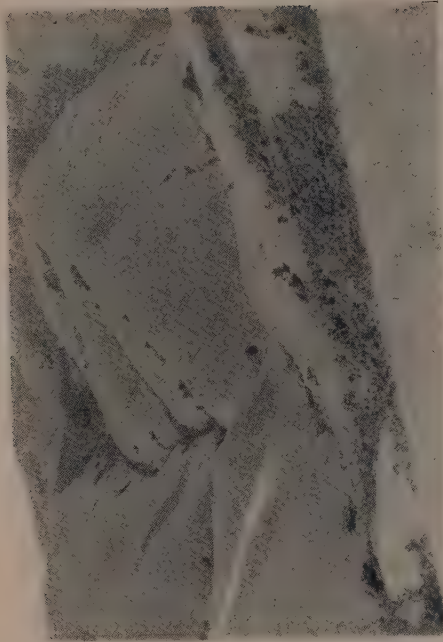
FIG. 24.—Mpwapwa. Hay field and pasture developed after clearing dense deciduous thicket (see background). Grassland with scattered trees.



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FIG. 26. Typical deciduous thicket vegetation on a field uncultivated for 20 years.



H. J. van Rensburg.
FIG. 28. Western, Central Tanganyika. Typical undisturbed *Brachystegia/Isobertinia* woodland near Chaya, east of Tabora. *Andropogon schauinslandii* dominant, with *Hybanthus dissoluta* abundant locally. Area infested by tsetse fly.



H. J. van Rensburg.
FIG. 27.—Southern Tanganyika, Livingstone Mts., near Lake Nyasa. Fires frequent. Slopes covered by *Themeda triandra*, *Trachypogon plumosus* and other species. Forest relics in protected ravines.



H. J. van Rensburg.
FIG. 29.—Western Tanganyika. Secondary *Brachystegia/Isobertinia* woodland, near Itumba, south-west of Tabora. Dense regrowth occurs after felling for fuel.

IV. AGRICULTURE AND FORESTRY IN RELATION TO SOIL AND WATER CONSERVATION IN SIERRA LEONE

BY

F. C. DEIGHTON

It must be appreciated that no detailed vegetational or soil survey of Sierra Leone has yet been undertaken, and only scanty meteorological data are available for most parts of the country (and none at all for certain large areas).

Except for the Colony Peninsula, some 25 miles long and 10 to 12 miles broad, which is mountainous (up to 3,000 feet), the coastal strip is flat and low-lying, and the numerous river estuaries are bounded by extensive mangrove swamps. Up to 100 miles inland from the coastal strip, the western and southern parts of the Protectorate are relatively flat and less than 250 feet above sea-level, broken in places by ranges of hills rising to 1,000 feet or more. The general level of the land rises, further east and north, to over 1,000 feet, and the land becomes sharply undulating, with several hill ranges up to 2,000 feet or more extending in a general north-east to south-west direction, and two tall mountain masses (the Loma and Tingi Mountains) rising over 6,000 feet in the north-east and east.

Nowhere is the rainfall much below 90 inches a year. In the hills of the Colony Peninsula it varies from 150 to over 300 inches, more than 120 inches having been recorded at one place in a single month. Rainfall over most of the Protectorate varies between 95 and 130 inches, becoming somewhat lower in the north and north-east and rather higher in the south and south-east. In consequence, there are no fewer than ten major rivers, with several larger and many smaller tributaries, flowing through Sierra Leone (six of the rivers having their entire origin within its boundaries), and numerous swamps or marshy areas in all depressions and valleys throughout the country. All rivers and streams become greatly swollen as the rainy season advances, a rise of 25 to 30 feet over the dry season level being common, and extensive flooding regularly occurs.

The seasons are divided into wet and dry. The wet season lasts from about May to October, the heaviest rain falling in July, August and September. There is a marked drought about January-February during which the dry north-east harmattan wind blows for a period varying from a week or two to more than a month, or longer and more pronounced further north. Small but important variations in the length of the dry season occur, the dry season being of slightly longer duration in the north-west, where certain areas with the same annual rainfall as places further south have, in consequence, a heavier monthly precipitation in July, August and September.

It is certain that the original vegetation over the whole of Sierra Leone was forest, but this was long ago altered by the agricultural pursuits of the inhabitants. The result is that now one may say roughly the vegetation of the southern half of the Protectorate is forest or regrowth "bush," and the northern half is tall grassland or tall grass-orchard bush savannah in which a few forest islands occasionally remain.

The normal method of farming in the southern area is to fell the trees, burn them, and take one crop of rice (with which is usually interplanted cassava which matures the following year), and then allow the coppiced tree stumps to grow up again. In general, it may be said that, given 7-9 years' regeneration, soil fertility is adequately maintained under this system and (provided the slope is not too steep) no obvious soil erosion occurs. With a shorter period of "bush fallow," which is bound to happen as the population increases, there is rapid degradation to thin scrubby bush mixed with *Chasmopodium*, lalang (*Imperata*) and other grasses such as *Andropogon* spp., and crop yields decrease greatly.

It appears that natural bush regeneration in the north is much more difficult, and the forest rapidly changes to grassland savannah (*Chasmopodium*, *Andropogon* and other tall grasses). Fires become annual events, and the reversion to forest is completely checked. Complete prevention of fire, at least at an early stage, will result in re-establishment of forest. This is, however, rarely practicable. When areas of grassland are extensive and complete prevention of fire presents almost insuperable difficulties, it is considered wiser to advocate early burning to avoid the outbreak of uncontrollable and highly destructive fires which would almost certainly occur if the grass was left to the risk of ignition late in the dry season.

The grasslands can, however, be farmed periodically (with a 5 or 6-year fallow) without any marked further degradation, and there is nothing to suggest that grassland soils are not as good as forest soils for periodic arable cultivation: in fact, there is some reason to think that certain of them may even be better.

Certain special areas exist, outside the forest and general grassland savannah areas already mentioned. The most important is the *Lophira* orchard bush savannah of the Port Loko District, which is singularly infertile and often consists of no more than a thin soil over a lateritic pan. Others are the fertile Elephant grass (*Pennisetum purpureum*) grassfields of the Kissi Chiefdoms in the east, the grasslands of the sandy coastal areas in the south, and the *Borassus* palm savannah in the Tambakka Chiefdoms in the extreme north-west. Special soil variation may account for these.

Probably over 90 per cent of the population of Sierra Leone are peasant farmers, and the chief problems in connexion with soil degradation and erosion result from over-farming consequent on increase of population. At this stage, no better method of arable farming of upland soils can be suggested than the present native method of growing one annual crop (rarely, two or three in successive years is possible) followed by a fallow period of some 7 or 8 years during which the natural "bush" or grass vegetation becomes re-established and soil fertility is gradually restored to

its original status. The native farmer recognizes what tradition has proved to be the best length of fallow ; he also realizes that more steeply sloping land should not be farmed, or at least should be farmed less often. As population increases, however, the fallow period has perforce to be shortened and farming extends into the forest on slopes which were formerly recognized as being properly left undisturbed.

The problem, therefore, is how to fit a steadily increasing farming population into the small areas of land.

AGRICULTURAL AND FORESTRY CONSERVATION MEASURES

The Agricultural Department has encouraged the greater use of inland and littoral swamps for arable crops (of which rice is the most important and is the staple food in Sierra Leone), the restriction of upland arable farming to relatively flat land (with a long fallow period), the cultivation of permanent tree crops on the lesser slopes, and the complete prohibition of farming on steeper slopes.

The maintenance of inland swamps in good condition is dependent on a good constant water supply with avoidance of sudden flooding. Forest reserves on the catchment areas are designed to ensure this. Similarly, forest reserves on the catchment areas of the numerous large rivers in Sierra Leone are designed to prevent flooding in the heavy rains and to ensure water supplies throughout the dry season. It is thought that permanent tree crops (such as cocoa, coffee and oil palms) on the lower and more gradual slopes can adequately replace natural forest in this function. Unfortunately, forest reservations in the numerous major catchment areas of the country are by no means yet adequate — a matter well realized by the Forestry Department.

The mangrove swamps along the river estuaries are capable, when not too salt, of cultivation year after year giving high yields of rice ; many of the inland swamps are similarly capable of regular annual cultivation, often bearing a crop of rice in the wet and of sweet potatoes in the dry seasons, while certain other inland swamps and low-lying marshy places will at least bear a good rice crop after a much shorter fallow period than ordinary upland areas. Intensive vegetable cultivation in certain inland swamps, using compost made locally, is a further possibility in the vicinity of the larger towns.

Large areas of untouched mangrove forest, suitable for rice cultivation with no preparation other than clearing, still exist along the estuaries—especially of the rivers south-east of the Colony Peninsula. Their exploitation is being actively encouraged by the Agricultural Department. Loans sufficient to pay for the skilled labour in felling the mangroves are made to farmers by the Native Administrations (as a continuation, in recent years, of the original Government mangrove loan scheme), with arrangement for repayment when the land is in bearing.

It must here be mentioned that the tidal flow of the water creates a new erosion problem along the river banks in cleared riverine mangrove swampland. It is recommended that a protective line of mangrove should

be left along the bank of the river, though it is at the same time realized that such a belt of mangrove harbours monkeys which are very destructive to the rice and which need constant discouragement.

The possibilities are also being explored of increasing the area of swamp land available for rice cultivation in the littoral zone, by simple drainage of the extensive sedge-swamps which occur behind the mangrove swamps and which at present are uncultivated, apparently only because of bad drainage. Empoldering in saline littoral swamps is a further means of increasing the area of rice land ; a small amount of such empoldering has already been carried out by native farmers, and the Department of Agriculture is now experimenting in several areas with a view to initiating development on a larger scale.

Clearance schemes in suitable but hitherto unexploited or incompletely exploited inland swamps have recently been carried out at certain places in the Northern Province, the preliminary work of clearing being carried out by the Native Administration which then leases acre-lots of cleared swamp to local applicants. The success of the first inland swamp clearance schemes has created a demand for similar schemes to be inaugurated in other Native Administrations.

Concurrently, selection of higher-yielding strains of local and introduced varieties of rice continues, the pure selected seed being distributed to farmers in both deltaic and inland swamp areas.

Cattle management in the grassland areas of the north is at present on more or less of a ranching system. The possibilities of better management, including the use of artificial pastures and rotational grazing, are being explored and preliminary results show promise. If successful, such improved cattle management should eliminate the likelihood of degradation of the vegetation and soil erosion (which are otherwise very liable to occur), besides increasing the number of animals which can be supported per acre and offering the possibility of intensive small-scale arable cultivation of some of the land with the use of farmyard manure. The possibilities of good animal husbandry, using the local "Ndama" cattle tolerant to trypanosomiasis, in the more degraded "bush" areas in the south also seem hopeful.

Perhaps the greatest difficulty at the moment lies in the distribution of population and an antipathy to shift from over-farmed uplands to under-populated areas with more fertile land. This difficulty is enhanced by the small size of the numerous chiefdoms into which the Protectorate is divided. One result is that it is extremely difficult to obtain the consent of the local people for new forest reserves in precisely those parts of the country where, because of vegetational degradation due to over-farming which is in turn due to over-population, they are most immediately essential.

FOREST RESERVES

Forest conservation is effected by the creation of State Forest Reserves and of Protected Forests, the latter differing from Forest Reserves in that they come into the ambit of Native Administration development and that no Settlement Court procedure is required for legal constitution.

The approximate area, excluding water surfaces, of the Colony and Protectorate is 27,000 square miles. To date, while 36 per cent of the 250 square miles of the Colony (which is mostly mountainous) is Forest Reserve, little more than 3 per cent of the 26,750 square miles of the Protectorate is Forest Reserve or Protected Forest.

At the end of 1947, Forest Reserves totalled 830.2 square miles, of which 46.7 were constituted during 1947. A preliminary request for the reservation of a further 130 square miles in the Loma Mountains was also signed by the Tribal Authorities. Protected Forests totalled 79.2 square miles, of which 8 square miles were constituted during 1947. More Protected Forests could have been constituted but for shortage of trained staff to carry out the surveys.

SOIL CONSERVATION AREAS

A new development was inaugurated in 1945, when one chiefdom in the Kenema District was declared a "Soil Conservation Area" in which the Tribal Authority, with advice of the Agricultural and Forestry Departments and of the Provincial Administration, may make Orders restricting or prohibiting farming operations, etc. The first order made by the Tribal Authority prohibited the cutting or burning of vegetation for farming purposes on the slopes of eleven specified hills within the chiefdom. A survey of the chiefdom is being carried out by Agricultural and Forestry Officers.

Other chiefdoms have not been slow in following this example. In 1946 two more were gazetted as Soil Conservation Areas and orders were issued prohibiting the farming of certain named hills and of land in the vicinity of certain named rivers (the response of the local people to these orders by the Tribal Authority being most encouraging); while in 1947 two chiefdoms followed suit, though up to the end of the year the Tribal Authorities had not ratified the necessary Orders. These chiefdoms are situated in a region where grass has replaced the original forest and where a conservation measure of the first importance is the prevention of fierce annual grass fires by the controlled early burning of the grass. During the past year this was successfully carried out under the supervision of the Forestry Department, in seven chiefdoms.

SOIL CONSERVATION TEAM

Approval was given by Government, in 1947, for the formation of a Soil Conservation team in Sierra Leone, to consist of an Agricultural, a Forestry and an Administrative Officer, with the following purpose: to review the general position in regard to soil and water conservation; to ascertain which are the areas most urgently in need of treatment; to examine the causes of soil deterioration and erosion in those areas; and to indicate possible measures to remedy the position in those areas. The team will be made up of officers seconded from normal duties, and will start work as soon as staff is available.

SUMMARY

A brief account has been given of the geography and climate of Sierra Leone, together with an account of the general problems of soil degradation which are seen to result primarily from intensified use of the uplands for arable (mainly rice) farming consequent on increase in population.

The general measures which are being taken by the Agricultural and Forestry Department for the immediate relief of the situation are described. More detailed recommendations must await the results of the survey which it is hoped will be carried out in the near future by the recently approved Soil Conservation team.

V. SOME NOTES ON THE ECOLOGICAL STATUS OF SAVANNAH VEGETATION IN NIGERIA

BY

R. W. J. KEAY

THE whole concept of ecological change and the varying developmental status of plant communities is fundamental to a proper understanding of vegetation conservation. Conservation implies that agencies are at work which, if not checked or controlled, degrade the existing vegetation. Although the methods of control must, if they are to be effective at all, be very simple, and in keeping with the political set-up of the country, it is important that these methods should be based on a proper understanding of the ecology of the existing vegetation and of the degrading agencies. In Nigeria, cultivation, fuel cutting, grass fires and grazing are generally recognized as the main factors which degrade, but less is known about the ecological status of the present dry vegetation.

Although this paper deals only with Nigerian savannah vegetation, it seems likely that many of the principles, as well as some of the detail, apply equally to other parts of tropical Africa, it is therefore hoped that the observations and suggestions here made will be of more general interest.

PHYSICAL GEOGRAPHY

The River Niger, and its tributary the Benue, may be regarded as the most important geographical features of Nigeria. The two rivers divide the country into three natural regions which correspond more or less with the political regions—the Northern, Western and Eastern Provinces. North of the Niger and Benue lies the central Pre-Cambrian crystalline massif of Northern Nigeria which is a large irregular plateau, some 2,000 feet above sea level, with the Bauchi Plateau reaching a general altitude of about 4,000 feet and hills on it rising to nearly 6,000 feet. The central massif slopes away on all sides where it is covered by sedimentary deposits. To the south, west and east lie Cretaceous and Tertiary deposits, and to the north-east lie the Chad Group of sands and clays. Covering the whole of the northern part of Northern Nigeria (north of about latitude 12°) is a mantle of drift sand which was formed during an arid phase of the Quaternary period when desert conditions extended into Nigeria. To-day, under a considerably moister climate, no part of Nigeria has a mean annual rainfall of less than 14 inches, and the southern boundary of the Sahara is, at its nearest point, a hundred miles or more from the Nigerian frontier.

The highest ground in the Western Provinces is made up of Pre-Cambrian granites and gneisses which form the so-called Yoruba Uplands. To the south and in the valley of the Niger the basement complex is covered

by sedimentary rocks of the Cretaceous and Tertiary periods. The Nigerian coast line is very flat and is dominated by the Niger delta and the fringe of estuarine deposits and anastomosing creeks which extend on either side of the delta proper. The Cameroon Mountain is the only high ground on the sea board.

The Eastern Provinces of Nigeria are bounded on the eastern side by the Cameroon range of mountains which are composed mainly of Pre-Cambrian igneous, and more recent volcanic, rocks. The Cameroon Mountain (altitude 13,350 feet) itself is an active volcano, but is completely isolated from the main range of the Cameroon highlands. To the west of these mountains is a large plain of sedimentary rocks rising, steeply in places, to the escarpment which runs more or less north-south through Udi. It is in this escarpment that the coal-bearing Cretaceous rocks outcrop. Between the escarpment and the Niger is rolling country of easily erodible sedimentary deposits.

Nigeria lies wholly within the tropics, frost is unknown and temperatures are uniformly high. The north-east trade winds blow across Nigeria from the Sahara and are known as the *Harmattan*. During summer in the northern hemisphere, a south-west monsoon blows from the Gulf of Guinea and brings the rain. The dry *Harmattan* wind is seldom felt on the coastal areas of Nigeria even during the northern hemisphere winter when rainfall is sparse or absent. Further inland, however, the *Harmattan* is felt for longer and longer periods as one proceeds northwards and the monsoon period is correspondingly shorter and the annual rainfall less. Inland there is a local increase of rainfall on the windward side of the Bauchi Plateau and the Cameroons range, and a corresponding drop on the leeward side.

Total annual rainfall ranges from about 144 inches in places like Forcados (Debunscha just beneath the Cameroon Mountain has the abnormally high mean annual rainfall of 375 inches) to 14 inches at places like Geidam. As far as the vegetation is concerned the severity of the dry season is as of much importance as the mean annual rainfall. The severity of the dry season may conveniently be measured by the mean monthly relative humidity in the driest month (usually January or February) and the length of the rainless period. Unfortunately most meteorological stations in Nigeria have recorded relative humidity at 9 a.m. only, but even these figures give a valuable indication of the severity of the dry season.

A study of Nigerian vegetation in many localities, together with a study of available climatic data, indicates that the *climatic* limit of continuous Tropical Forest (*La Zone de la Forêt Dense* of French workers), that is excluding the forest "outliers" in moist valleys in the Savannah regions, coincides very roughly with a line linking all stations with a mean annual rainfall of at least 50 inches and a lowest mean monthly 9 a.m. relative humidity of not less than 70 per cent. North of this line, dry-season relative humidity falls very rapidly although mean annual rainfall may increase locally. Thus a station such as Ibadan with a mean annual rainfall of 51 inches and a lowest mean monthly relative humidity of 75 per cent is just within the Forest region, but Minna with a higher rainfall (57 inches) is well within the Savannah region owing to the much lower mean monthly relative humidity (35 per cent in the driest month). Further north the mean annual

rainfall and dry season relative humidity become progressively lower and the rainless period longer and longer.

POPULATION

Nigeria has a growing population of about 23 millions and a population map of Africa shows that, apart from the Nile Valley and urban centres such as Capetown, it is the most densely populated part of Africa. There is good reason to believe that it has been fairly densely populated for at least several centuries. The most densely populated parts of Nigeria are the northern part of the Northern Provinces, and the western part of the Eastern Provinces. The population of the Western Provinces is also large but most of it is concentrated in large towns leaving sparsely populated areas between them ; all but one of the eleven towns in Nigeria with a population of more than 40,000 are in the Western Provinces. The southern part of the Northern Provinces and the eastern part of the Eastern Provinces are relatively sparsely populated, but there is evidence that these areas, together with the sparsely populated areas between the large towns of the Western Provinces, have been more densely populated from time to time in the past.

This relatively dense population has of course had its effect on the vegetation, so much so that, apart from swamps and mountainous regions, it is true to say that little or no truly virgin forest or woodland exists in Nigeria to-day.

VEGETATION ZONES

A recent paper (Keay, 1949), gives an outline account of the vegetation zones of Nigeria and is accompanied by a provisional vegetation map. Following the work of Chevalier (1900, 1935, etc.) and other French workers, the vegetation of Nigeria is described by reference to the following zones :—

The Forest Regions.

1. Mangrove Forest and Coastal Vegetation.
2. Freshwater Swamp Forest.
3. Rain Forest.
4. Dry Forest.
5. Derived Savannah.

The Savannah Regions.

1. Southern Guinea.
2. Northern Guinea.
3. Sudan.
4. Sahel.

Montane Vegetation.

These are the main Vegetation Zones, not the Geographical Regions (which are known by similar names) and not the actual Vegetation Types. In general the Vegetation Zones correspond to climatic zones, but in some parts edaphic or biotic factors are dominant over a sufficiently large and

continuous area for that area to be mapped separately. Thus the Mangrove and Coastal types are mapped separately, so too are the Freshwater Swamp Forests of the creeks behind the Mangroves. In the Derived Savannah zone biotic degradation is so widespread, and the resulting vegetation so characteristic, that the zone is worthy of mapping.

Within each zone there are, of course, numerous variations in the actual vegetation types. Outliers of high forest, for instance, occur in moist sites in the Southern Guinea Zone, and small areas of derived savannah can always be found in the northern part of the Dry Forest Zone. Farmlands and secondary regrowth can be found almost anywhere and in some areas farming is so intensive that all natural vegetation has been destroyed or completely changed. Wide areas of intensively cultivated ground surround most of the large towns, particularly in the Northern Provinces. In Owerri, Rivers and Calabar Provinces the widespread cultivation of oil palms has produced a very characteristic type of vegetation, often called Oil Palm Bush, and quite unlike the original Rain Forest. Cacao and cola plantations have completely changed the appearance of much of the Western Provinces.

The boundaries between the zones are not always sharply defined. This is due not so much to the intermediate types, though these do of course exist, but rather to the intermingling of communities of the two zones. In practice there is nearly always a belt, 10 or more miles wide, in which the two types are more or less equally represented.

In the present paper we are concerned mainly with the ecological status of the vegetation and the degrading factors at work in the various zones. For a fuller descriptive account of the vegetation zones, reference should be made to the earlier paper.

FOREST AND SAVANNAH IN NIGERIA

The word *Forest* is used here for vegetation in which woody plants are dominant and form at least one dense and usually more or less evergreen layer beneath which grasses are absent, save for a few specialized species such as *Leptaspis cochleata*. Many of the trees and shrubs have relatively thin bark and are easily killed if for any reason they are exposed to fire. Owing to the absence of grass and to the more or less evergreen nature of the understorey, fire does not normally enter forest vegetation. In most parts of Nigeria, however, when forest is cleared for cultivation, the farmer cuts the smaller trees and stacks the cut branches at the bases of the larger trees; when dry enough the branches are burnt and the larger trees easily killed. Once the forest is opened for cultivation savannah grasses may invade the fallow land; sooner or later the grass is fired.

There is a wide range of physiognomic types for which the word *Forest*, as here defined, may be used. A number of terms have been standardized for use in Nigeria by the Forest Department (1948); terms such as *High Forest*, *Secondary Forest*, *Forest Regrowth*, *Climber Tangles*, etc. The word *Forest* is used only in this sense, and never for *Savannah* vegetation where the word *Woodland* is more appropriate.

The word *Savannah* is here used for vegetation in which grass is dominant in the herb layer, and the trees and shrubs, often widely spaced,

possess some degree of fire-tolerance. Grass fires occur almost every dry season in areas of savannah vegetation. A number of physiognomic types of savannah may be recognized and the Nigerian Forest Department's Handbook standardizes descriptive terms for these. In *Savannah Woodland* the trees form a closed or almost closed canopy, but in *Open Savannah* they are widely separated; *Open Savannah Woodland* is an extremely useful term to describe the common type in which the trees grow quite close together but seldom form a closed canopy. These terms are used merely to describe physiognomic types without reference to specific composition or developmental status.

DERIVED SAVANNAH

Primarily the vegetation of Nigeria is determined by climate; thus forest vegetation is widespread in the wetter southern part of Nigeria, while savannah types dominate in the drier north. The actual distribution is, however, profoundly influenced by other factors, particularly the soil, grass fires and farming. The soil of valleys in the savannah regions may remain sufficiently moist in the dry season for such sites to support strips or islands of forest, known in Nigeria as *Forest Outliers*.

There is little doubt that the combined effects of native agriculture and grass fires can bring about, and indeed have brought about, the degradation of High Forest to a savannah type which may conveniently be called *Derived Savannah*.

When farmland in the Forest Regions is left fallow for several years it is usual for climbing shrubs and quick growing trees (such as *Musanga*, *Triplochiton* and *Albizia* spp.) to establish themselves, and if left unfarmed the secondary forest soon develops into High Forest, often rich in economic timber trees.

Under certain conditions, however, grass may invade the fallow land, particularly where the soil is poor and the period between bush fallows is short. At first there are grassy fallows of species such as *Imperata cylindrica*, *Ctenium elegans* and tall *Andropogon* spp. Relict forest trees remain for a while as well as regrowth forest species such as *Trema guineensis*, *Phyllanthus discoideus*, and *Newbouldia laevis*. The invasion by the tall savannah grasses means, however, that the fallow land is soon swept by fire. The fire kills out many of the less resistant forest species and encourages still further the growth of grasses which can send up new shoots as soon as the fire passes. Fires thus become fiercer, and more and more forest species are killed out. Among the last forest species to remain in the grassy fallows are the oil palm, *Phyllanthus discoideus*, *Dialium guineense* and the climbing *Combretum* spp. If fire-tolerant savannah trees are available, these will colonize the grassy fallows and eventually the original high forest is replaced by derived savannah with only vestiges of its past vegetation. Derived savannah occupies large areas in Nigeria both within and to the north of the Forest Region.

In the Western Provinces it is usual to find relict areas of high forest on quartzite hills and ridges surrounded by derived savannah on the plains. The forest has escaped because the rocky soil of the hills is not suitable for farming. Farms were, and are still, concentrated on the plains, and it is here

that degradation to derived savannah has taken place. On better soils supplied with moisture from rivers and streams during the dry season, high forest, much of it secondary regrowth, may still remain. This is apparently because farming has not been able to bring about the change from forest to savannah owing to the better soil.

In the densely populated Eastern Provinces, particularly in Onitsha Province, derived savannah is widespread. Here the heavy population has caused the degradation of forest to derived savannah on a large scale. Forest both of the Dry Forest and Rain Forest Zones has been degraded in this way. Fairly extensive, but now more or less isolated areas of Dry Forest still exist south of the Benue in Kabba Province, directly to the north of the derived savannahs of Onitsha Province.

Most of the villages in the rolling country of Onitsha Province are situated on the high ground between the valleys. Around and within these villages a number of large forest trees are found. A few of these trees, such as *Treculia africana* and *Chrysophyllum albidum* have certainly been planted but the majority are obviously relict trees from what was once continuous high forest. The species in the villages and in the small remaining patches of forest outside the villages (e.g. "juju" bush, and the Mamu River Forest Reserve) indicate that the original forest was of the wetter Rain Forest type; *Mimusops* spp., *Gossweilerodendron* and *Cylicodiscus* may be cited as examples. Climatic data clearly indicate that the climate is still that of the Forest Region (for example, Enugu has a mean annual rainfall of 72 inches, and mean January monthly 9 a.m. relative humidity of 74 per cent).

Patches of derived savannah occur also isolated within more or less continuous high forest in various parts of the Forest Region. Such derived savannah often lacks many of the fire-tolerant savannah species which are typical of derived savannah on the northern edge of the Forest. A special case is that of the Sobo Plains in South Benin. Here there are large areas of grassland (dominated by *Loudetia arundinacea*) surrounded by continuous forest, with small islands of forest within the sea of grass. The origin of the Sobo Plain grasslands is still rather obscure, although there are good reasons for believing them to have been caused by over-intensive farming (see Keay and Onochie, 1947). It is, however, perfectly clear that the grasslands are maintained as such by fire which inhibits the spread of fire-tender forest species. Fire-tolerant savannah trees are absent because the Plains are completely isolated well within the Forest zone, and consequently the vegetation is almost entirely made up of ruderal herbs such as may be found on almost any bare ground in the towns and farms of the Forest Region.

Derived savannah is therefore quite obviously a secondary type which owes its existence to biotic factors. If fires are uniformly fierce over an area of derived savannah the vegetation is relatively stable and may be regarded as a *sub-climax*. Often, however, derived savannah consists of a mosaic of different seral communities at different stages of degradation or recovery, determined by the local severity of the fires and other local factors such as soil and previous farming history. There is evidence to prove that derived savannah goes back to forest wherever fires are excluded, although recovery may be slow.

THE FOREST/SAVANNAH TRANSITION

Wherever forest and savannah vegetation adjoin there is usually either a sharp boundary with abundant climbers draping the forest margin, or else a characteristic transitional belt. The sharp boundary may sometimes be due to an abrupt change in topography and soil, but more usually it is caused by grass fires. Where there is a transitional belt between the forest and the savannah, this usually consists of a mixture of fire-tolerant savannah, trees and fire-tender forest trees forming a closed canopy over a mixture of savannah grasses and forest shrubs and herbs; such vegetation is known in Nigeria as *Transition Woodland*. Very often the transition woodland belt represents a stage in the return from derived savannah to high forest. This is well seen in areas such as the Ijaiye Forest Reserve (about 20 miles north-west of Ibadan), through which the present-day boundary between the Dry Forest and Derived Savannah Zones can clearly be traced. Almost every patch of forest is separated from the savannah by a strip of transition woodland in which young forest trees such as *Erythropsis barteri* and *Cola cordifolia* are growing up with old savannah trees such as *Daniellia oliveri* and *Lophira alata*; a number of other trees such as *Anogeissus schimperi* and *Malacantha alnifolia* are particularly characteristic of such vegetation. Late stages of this succession can be seen in which large *Anogeissus*, completely without regeneration, remain in the re-established high forest.

A rather different example is afforded by a part of the Akpaka Forest Reserve in Onitsha where an area of fallow farmland with abundant grass and regrowth shoots of savannah species has been protected from fire for about 25 years. Here the savannah trees, particularly *Daniellia oliveri*, *Lophira alata* and *Hymenocardia acida*, have grown up very densely, grass has been excluded, but there has been little or no space for forest trees to enter. A number of forest shrubs, particularly *Gaertnera paniculata*, are established, but it is reasonable to suppose that there will be no significant change in the composition of the tree-layer until some of the savannah trees become moribund.

These two examples are both from areas where the climax vegetation is undoubtedly high forest and where relicts of forest are not confined to streams and other moist situations; indeed in the Ijaiye Forest Reserve the best areas of high forest are found on uncultivable rocky hills, and in Onitsha relict forest trees and patches of forest are deliberately preserved in the villages. In both areas the transition woodland is clearly a sub-seral type.

Transition woodland is also found, however, in drier savannah country on the margins of fringing forest by streams. Under these conditions the transition woodland often appears to be relatively stable, though it may easily be converted to open savannah by cultivation followed by grass burning.

The term *ecotone* may sometimes be used justifiably for certain types of transition woodland. More usually, however, a belt of transition woodland between forest and savannah represents a definite sub-seral stage, rather than a straightforward mingling of components of two adjoining communities of equal status. The use of the term *ecotone* is, however, most

unfortunate when applied, as it often is, to the wide belt where the Forest and Savannah Regions adjoin. The Forest and Savannah Regions are not, as the term ecotone suggests, separated by a belt of vegetation intermediate in character between forest and savannah. Narrow belts of such intermediate vegetation (transition woodland) do, as we have seen, exist locally where forest and savannah adjoin, but the boundary between the Forest and Savannah Regions is merely an arbitrary line dividing "Forest with patches of Savannah" from "Savannah with patches of Forests."

It is perhaps generally true that, wherever two climatic regions adjoin, the vegetation consists of a mosaic of communities representative of each region, with the drier type occupying the less favourable and the moister type the more favourable sites, rather than an intimate mingling of the species in an intermediate type of vegetation. The mosaic arrangement is clearly seen in many parts of Nigeria.

The so-called ecotone between the Forest and Savannah Zone consists in fact of an intricate mosaic of secondary forest and derived savannah communities. In well-populated areas, as for instance around Ibadan, it is possible that the mosaic has reached a state of balance under the present conditions of grass fires and farming. At all events there is no obvious indication that the patches of forest tangles and secondary forest are rapidly giving way to the derived savannah. In areas which are populated less now than in the past, there is often clear evidence that forest vegetation is locally recolonizing derived savannah.

THE GUINEA SAVANNAH ZONES

Going north through the Derived Savannah Zone, the observant traveller will notice that forest vegetation becomes confined to moist valleys and stream sides and that oil palms are similarly confined to these sites. He will notice too that savannah vegetation, mostly with tall grass and broad-leaved trees, is everywhere dominant even in sparsely populated country. The dividing line between the Derived Savannah (*District préforestier* of Aubréville) and the Guinea Zone proper (*Zone guinéenne ou des savanes sub-forestières avec galeries*) is nowhere sharp, but it seems to correspond more or less with the arbitrary line, mentioned on page 58, linking all stations with a mean annual rainfall of at least 50 inches and a lowest mean monthly 9 a.m. relative humidity of not less than 70 per cent. North of this line it is fairly clear that Forest, as defined in this paper, is not the climax, but it is a mistake to regard the present day open savannah as climax. In the Southern Guinea Zone patches of relatively little disturbed vegetation in areas which have not been heavily populated suggest that the climax vegetation of the zone may have been something like the transition woodland described on page 63. As the term, *Transition Woodland*, is obviously unsatisfactory for a climax type, the term *Light Forest* is proposed to correspond with Aubréville's *Forêt Claire Tropicale* (1938). Some good examples of this type of vegetation can be seen in the Upper Ogun Forest Reserve about 80 miles north of Ibadan. Although open savannah woodland of the Southern Guinea type is wide-spread, there are in this reserve quite considerable areas where fire-tender trees such as *Chlorophora excelsa*,

Albizzia zygia, *A. coriaria* and *Phyllanthus discoides* are mixed with typical savannah trees such as *Azelia africana*, *Daniellia oliveri* and *Pterocarpus erinaceus*. Much of the ground is covered with sparse but tall grass, but there are numerous erect and scandent shrubs, such as *Macrosphyra longistyla*, *Phyllanthus floribundus* and *Opilia celtidifolia*, which locally form dense tangles.

Throughout most of the Southern Guinea Zone, however, there is abundant evidence of past and present farming. If the climax was Light Forest as suggested above, then there is no doubt that cultivation and fires have successfully eliminated most of the fire-tender trees and shrubs and have led to the complete dominance of tall tussocky grasses in the herb layer. An interesting feature of the Southern Guinea savannahs is that a considerable proportion of the trees are closely related to congeners in the Forest Regions—*Lophira alata* and *Terminalia glaucescens* are good examples. Another interesting feature is that most of the trees, particularly the commonest such as *Daniellia oliveri* and *Lophira alata*, are extremely fire-tolerant.

Guinea savannah which has been farmed within the last 50 years or so has a characteristic structure. Larger trees of useful species such as *Parkia oliveri*, *Butyrospermum parkii* and *Vitex doniana* stand above the younger regrowth of species which were eradicated or coppiced when the bush was cleared for farming. Taken over wide areas, such vegetation appears to be stable enough under the present-day conditions of farming and grass fires, although of course there are constant local changes due to the initiation of sub-series by farming and the varying intensity of the fires.

The Northern Guinea Zone is a western extension of the drier "miombo" woodlands of East and Central Africa. *Isoberlinia doka*, *I. tomentosa*, *Monotes kerstingii*, *Swartzia madagascariensis*, *Combretum binderianum* and *Uapaca somon* are among the most characteristic and abundant trees of this zone.

An appreciable proportion of this zone has been little disturbed by farming, as there are many extensive waterless plateaux. In these sparsely populated tracts, *Isoberlinia* and its associates form open broad-leaved deciduous woodland, 30 to 40 feet high on the average, with grass 4 to 5 feet high completely dominant in the herb layer; there is nothing approaching a continuous shrub layer, though climbers, especially *Opilia celtidifolia*, occur locally.

Experiments in a forest reserve near Kaduna have shown that a small plot of *Isoberlinia* woodland has changed little when protected from fire for 8 years but that in an adjacent plot, which has been burnt annually late in the dry season for the same period, a large proportion of the *Isoberlinia doka* has been completely killed, together with several other species. These results, although based on a very limited experiment, are very significant and bear out observations made in many parts of the country. They indicate that grass fires in the tracts of sparsely populated *doka* woodland cannot be so very fierce every year, certainly not as fierce as in the wetter Southern Guinea Zone where the grass is taller and the savannah trees definitely more fire-resistant. The experimental results also provide an explanation why in

densely populated and farmed areas *Isoberlinia* is sometimes a rare plant. In course of time it is apparently replaced on the fallow farmlands by more tolerant species such as *Terminalia avicennioides* which, if allowed, may form a kind of understorey between the widely spaced large "farm trees" such as *Parkia* and *Butyrospermum*. At Kishi and other towns in northern Oyo Province which lie near the southern edge of the Northern Guinea, *Daniellia oliveri* is the commonest species in the farm fallows and has apparently replaced *Isoberlinia* which is still dominant in the sparsely populated bush between the towns.

There is therefore good reason to believe that the open woodlands of *Isoberlinia* and its associates in sparsely populated areas are substantially similar to the climatic climax of the zone. In these areas grass fires have probably opened the canopy and limited the development of scandent shrubs, but the resulting sub-climax open woodland is stable under present conditions and is only slightly changed from the true climax. In more densely populated areas the vegetation has of course been changed and secondary growth may lack some of the characteristic woodland species.

THE SUDAN ZONE

The Sudan Zone has long been recognized as a well-marked geographical region characterized both by climate, vegetation and its people. In Nigeria the Sudan Zone has been inhabited for centuries and it is difficult to find any vegetation which has not been profoundly modified by biotic factors.

Around the towns, agriculture is very productive and in many places the farmlands are used annually and are manured by sweepings and excreta brought out from the towns. Beyond the farms the savannah vegetation is usually quite open, although several species of tree attain good heights (50 to 60 feet or more).

Sudan Zone savannah is characterized by an appreciable proportion of fine-leaved species (e.g. *Albizzia chevalieri*, *Acacia* spp., *Sclerocarya birrea*) mixed with broad-leaved trees (e.g. *Lannea microcarpa* and *Combretum* spp.) mostly of Guinea affinity. The common grasses are shorter and more feathery than in the Guinea Zone and after fire the ground remains bare until the rainy season begins; in Guinea savannah fresh green shoots appear within a few days of the fire passing and often several weeks before the rainy season begins.

Most of the Sudan zone vegetation consists of complicated mosaics of numerous secondary seral communities at various stages of development and influenced by various biotic factors, or combination of factors. Regarded as a whole, a large area of such savannah appears to be relatively stable under existing conditions, but if the components of the mosaic are considered individually, ecological change is everywhere apparent. Rocky areas where biotic disturbance is relatively slight carry quite dense mixed woodland of trees up to 30 or 40 feet high, with little grass but abundant deciduous woody climbers such as *Combretum micranthum*, *Acacia ataxacantha* and *Capparis corymbosa*.

It is possible that the climax vegetation of the Sudan Zone of Nigeria consisted of a dense understorey of dry zone deciduous shrubs and climbers



H. J. van Rensburg.
FIG. 30. Suigila District, Central Province. Land deterioration caused by bad agricultural practices and uncontrolled grazing.



H. J. van Rensburg.
FIG. 32.—Laheri, Central Province. Grassland with scattered trees under natural conditions maintained by fire. Because of acute water shortage, the land is grazed only periodically by nomadic tribes.



H. J. van Rensburg.
FIG. 31. Matamondo, Central Province. Effect of fire on vegetation. Woody plants severely damaged by fierce grass fire. Dense growth of *Cynodon plectostachyum* among the thorn bushes.



H. J. van Rensburg.
FIG. 33.—Southern Tanganyika. Hagafiro river waterfall near Njombe Stream.



H. J. van Rensburg.
FIG. 34. Urambo, Western Province. Typical *Brachystegia/Isobertinia* woodland being cleared by mechanical means for cultivation of ground nuts and other crops.



H. J. van Rensburg.
FIG. 35. Bush-clearing at Kongwa for groundnut production. Typical vegetation of Central Tanganyika, deciduous thicket consisting mainly of species of *Commiphora*, *Acacia* and *Grewia*.



H. J. van Rensburg.
FIG. 36. Large baobab (*Adansonia digitata*) tree at Kongwa being removed for groundnut cultivation. Side roots first cut by bulldozer before tree is pulled over.



H. J. van Rensburg.
FIG. 37. —Aicho Escarpment, Mbulu Highlands, Northern Province. Deterioration of potential forest land due to faulty methods of cultivation and overgrazing on steep slopes.



Fig. 1. Erosion in the field. The erosion is most pronounced in the center and left side of the frame, where the soil has been washed away, leaving deep channels. The background shows a line of trees and a hazy horizon.

with sparse grass, with larger emergent trees forming an open canopy. Similar vegetation exists to-day in other parts of Africa (e.g. the Shesheke district of south-western Northern Rhodesia) with a climate similar to the Nigerian Sudan but with only a sparse population. Although in itself stable, such vegetation is quickly destroyed once fires are started, as the dry understorey can burn fiercely, and is degraded to an open savannah type with grass dominant in the herb layer. This is taking place to-day in parts of Northern Rhodesia but may well have happened in Nigeria long ago.

The southern limit of the Sudan Zone coincides very closely with the limit of drift sand which covers much of the northern part of Northern Nigeria. Since this drift was formed in Quaternary times, the climate has become moister and the sand has become stabilized by vegetation; old stabilized dunes can still be traced in many parts of the Sudan Zone. It is therefore obvious that when the natural vegetation is removed in farming, there will be some local movement of sand in the dry season when the crops have been reaped. This has led people to believe that the Sahara is encroaching in Northern Nigeria. In fact, the northern boundary of Nigeria is separated from the desert by a wide zone of Sahelian woodland vegetation, and the excellent crops of the rainy season allow the Sudan Zone to produce a large surplus of food for export.

SUMMARY

Varied opinions of the ecological status of Nigerian savannah vegetation have been expressed. Some have suggested that the present-day savannah is a climax type, while others maintain that it has all been degraded by human influence from dense high forest. A correct diagnosis of the existing status is clearly fundamental in plans for conservation.

In this paper a brief outline of the Vegetation Zones of Nigeria is given and the ecological status of savannah vegetation within each zone is discussed. Nigeria has a growing population of 23 millions and little or no truly virgin forest or woodland exists to-day. Regarded as a whole, a large area of modified savannah may appear to be relatively stable under existing conditions, but if the components of the mosaic are considered individually, ecological change is everywhere apparent.

There is reason to believe that the *climatic* limit of continuous Tropical Forest coincides very roughly with a line linking all stations with a mean annual rainfall of at least 50 inches and a lowest mean monthly 9 a.m. relative humidity of not less than 70 per cent. South of this line there is a wide zone of Derived Savannah with relicts of forest on high ground away from the streams. Patches of derived savannah also occur within the Forest Zone as it is to-day. The term *derived savannah* is used for savannah which has obviously been derived from high forest.

In the Southern Guinea zone, high forest is confined to exceptionally favourable moist sites, and savannah is continuous on high ground. It is possible that the climax here is Light Forest with a mixture of fire-tolerant savannah trees and fire-tender forest trees forming a closed canopy over a mixture of savannah grasses and forest shrubs.

Wide areas of the Northern Guinea zone are sparsely populated, and

the *Isoberlinia* woodlands, with their continuous grass cover and sparse shrub layer, are probably not very different from the climax.

The Sudan zone has been inhabited for a long time. It is possible that the climax may be similar to present-day vegetation in a sparsely populated but otherwise similar area of Northern Rhodesia. There in the Shesheke district deciduous shrubs and climbers form a dense understorey beneath large emergent trees which form an open canopy. Although in itself stable, such vegetation is quickly destroyed once fires are started and is degraded to an open savannah type with grass dominant in the herb layer. This is happening to-day in parts of Rhodesia, but may well have occurred in Nigeria long ago.

The possibility must always be borne in mind that human interference is so ancient and widespread in Nigeria that climax vegetation may never have had an opportunity of developing over wide continuous areas in the present climatic era.

BIBLIOGRAPHY

- AUBREVILLE, A. 1938. La forêt coloniale. Les forêts de l'A.O.F. *Ann. Acad. Sci. Col.* 9. Paris.
- CHEVALIER, A. 1900. Les zones et les provinces botaniques de l'A.O.F. *C.R. Acad. Sci. Paris.* 130.
- CHEVALIER, A. 1933. Le territoire géo-botanique de l'Afrique tropicale nord-occidentale et ses subdivisions. *Bull. Soc. Bot. Fr.* 80.
- KEAY, R. W. J., and ONOCHIE, C. F. 1947. Some observations on the Sobo plains. *Farm and Forest* 8. pp. 71-80.
- KEAY, R. W. J. 1949. An outline of Nigerian vegetation. *Inedita.*
- NIGERIAN FOREST DEPT. 1948. The vegetation of Nigeria. Descriptive terms. Lagos.

VI. MANAGEMENT AND CONSERVATION IN THE ANGLO-EGYPTIAN SUDAN

THIS note is based on information extracted by the Editor at the request of the Chief of the Research Division of the Ministry of Agriculture of the Anglo-Egyptian Sudan from the Report of the Soil Conservation Committee, 1944.

The Governor-General of the Anglo-Egyptian Sudan in December, 1942, set up the Soil Conservation Committee with the following composition and terms of reference :—

Chairman

J. D. Tothill, C.M.G., D.Sc., Director of Agriculture and Forests.

Members

Lt.-Col. C. P. Fisher, M.R.C.V.S., Director, Veterinary Service.

J. Smith, B.Sc.(For.), Chief Conservator of Forests.

G. Andrew, M.Sc., Government Geologist.

G. M. Hancock, O.B.E., Sudan Political Service.

B. Kennedy-Cooke, M.C., Sudan Political Service.

Terms of Reference

- (a) To report on the present situation in the Sudan with regard to soil erosion and desiccation and the availability of rural water supplies for the human and animal population.
- (b) To make recommendations in respect of any of the above matters and of any measures of legislation or taxation which may be required for the carrying out of such recommendations.
- (c) To draw up a programme of work covering a stated period of years for the implementation of the recommendations.
- (d) To provide estimates of the capital cost of carrying out the programme and of the future maintenance costs involved.

The following programme designed to circumscribe the nature of the enquiry was agreed to :

A. COLLECTION OF FACTUAL DATA.

- 1. To arrange for a statement of facts regarding changes of climate and environment in glacial and historical times, due to changes in the basic climate or to the activities of man and his domestic animals.

2. To arrange for the preparation of density maps for human beings and for domestic animals.
3. To collect information on the distribution of wells and hafirs of all types in each Province, and to review the possibility of developing rural water supplies for domestic and live-stock use over a 5-year period.

B. SUBJECTS FOR DISCUSSION.

1. Desert Creep.—If the facts show a southward creep, to review the steps that might be taken to arrest this creep such as :
 - (a) the control of animal grazing, particularly goats and camel ; and
 - (b) the planting-up of belts of forest in principal areas.
2. Tokar dune formation and the Tokar position generally.
3. The Red Sea Hills.
4. The Grassland/*Acacia* cycle in the Gedaref areas, with proposals for its planned management.
5. The Grassland *Acacia* cycle in the main rain dura-growing areas of the Blue Nile Province, with proposals for the orderly management of these important areas, including fire control and provision of water supplies,
 - (a) on the clay plains ; and
 - (b) in the river valley above Sennar.
6. The Grassland/*Acacia* cycle in the Upper Nile Province, with proposals for its orderly management in the difficult areas concerned, including the control of fires, the provision of water supplies, the better control of cattle, and where necessary, the moving of villages.
7. The agricultural lands of Kordofan Province, with proposals for the prevention of erosion by contour bunding, contour strip planting, afforestation, control of animal grazing, etc.
8. The annual grass problems in Equatoria Province, with a view to deciding whether or not controlled early burning should be adopted. The Imatongs in particular to be reviewed in order to have the same policy for both the Uganda and the Sudan slopes.
9. The reafforestation of catchment areas, yielding water supplies for important groups of people in the Red Sea Hills, the Fung, Kordofan, Darfur and Equatoria ; with a suggested 5-year programme of work and estimate of its cost.
10. Special reclamation projects, such as the building of dams in Kordofan, with a list of such projects considered suitable for inclusion in the 5-year plan.
11. The existing forest policy of the Government in its relation to soil and water conservation.
12. The question of the perimeter protection of towns, with a suitable programme.

13. Rural communities and water supplies.
14. The general question of stock in the Sudan in relation to soil deterioration and erosion, with proposals for the orderly exploitation of the cattle industry in its relation to the soil conservation problem. The provision of cattle markets, the taxation of cattle and all related subjects.
15. The general question of taxation in its relation to soil conservation, with proposals designed to spread equitably, as between individual communities, provinces and the Central Government, the costs of the 5-year programme recommended.

C. PROGRAMME.

To draw up a detailed 5-year programme showing total cost and how it might be shared between the Central Government, the provinces, and the communities concerned.

D. ORGANIZATION.

To recommend a suitable organization for carrying out the programme.

THE CLIMATIC BACKGROUND

The Sudan Report introduces a discussion of this aspect, one which has a very considerable bearing on the whole question of conservation in Africa. There has been much discussion of the alarming and increasing rate of desiccation in the African continent. Lake Rudolf is receding rapidly. Karamoja in Uganda shows signs of advancing aridity, and villages have been buried by sand on the southern fringes of the Sahara. Anyone responsible for recommending conservation measures must first understand what is really happening, whether one is in fact dealing with a new change for the worse in basic climate, or whether the advance of aridity is due to the habits of mankind and his domestic animals. The Sudan Report states the main reasons for assuming that there has been no change in basic climate during historical times.

For the last 50,000 years the world has undergone a series of alterations in basic climate related to four successive advances and withdrawals of an ice sheet over much of Europe and North America. In those countries the climate was alternately frigid and mild as shown by the fossil record. In tropical Africa the climate was alternately wet and arid. Toward the close of the period there have been minor fluctuations of the area covered by ice and Greenland still has an ice cap, but these minor events do not upset the general truth of the statement that, since the most recent withdrawal of the ice sheets, there has been no major change in basic climate in any part of the world.

In Kenya, Uganda and the Northern Nile valley the main facts are well known and it is now possible from a combination of all sources of information to make a general statement of the succession of events. Throughout Glacial times there was repeated change of basic climate consisting of wet periods alternating with dry ones. Each succeeding wet

period was less wet and of shorter duration than the preceding one, and each succeeding dry period appears to have been shorter and possibly less extreme than its predecessor as shown on Diagram 1.

One of the minor wet periods recorded in the beaches of Lake Nakuru is thought to have occurred in a short period commencing about 850 B.C., that is to say, in Recent rather than Glacial times.

Wayland, Leahey and Lowe, after discussion in 1941, agreed that the following table is the best summary of events that could be made on information available at that time. The dates must be accepted with caution and were put in by Leahey merely to indicate to his Coryndon Museum visitors the order of time involved.

DIAGRAM 1

				<i>Present climate</i>	<i>Date v. approx.</i>	
Holocene or Recent				Nakuran minor wet	850 B.C.	Neolithic
				Present climate	2,000- B.C.	
Pleistocene or Glacial Upper				Makalian wet	2,000-6,000 B.C.	Palaeolithic
				Dry	6,000-10,000 B.C.	
				Gamblian pluvial	10,000-70,000 B.C.	
				Dry	70,000-80,000 B.C.	
Middle Pleistocene				Kamasian pluvial	80,000-250,000 B.C.	
				Dry	250,000-300,000 B.C.	
Lower Pleistocene, Pliocene				Kisegian pluvial	300,000-500,000 B.C.	

From a conservation point of view the main thing to note is that the final main wet period, the Makalian, occurred in Neolithic times and that it has been succeeded by the Recent period during which Lake Nakuru once became higher than its normal upper level, but during which no change of basic climate has occurred.

In Egypt it has been shown by Sandford and Arkell that there was abundant run-off from wadies on the right bank of the Nile during the Kamasian pluvial of the above table and that later these tributaries never again reached the same volume.

The distribution of Neolithic implements and semi-fossil snail shells over the Libyan Desert suggests that rainfall was sufficient to allow passage of Neolithic travellers and perhaps some settlers in favoured spots. It was not heavy enough, however, to produce flowing tributaries to the Nile. As compared with the aridity of to-day, however, the basic climate of Neolithic times was clearly wetter. The most northerly record of the sub-fossil occurrence of *Limicolaria caillaudi* is on a mound near station No. 10 at Abu Hamid, thus representing a shift of the 500 mm. isohyet northwards through 5° 30' of latitude or approximately 600 kilometres.

In Abyssinia, according to Nilsson, a local ice cap on the Semien Mountains reached its maximum during the Gamblian pluvial and receded steadily to disappear by the end of the Makalian or fourth main wet phase.

CONSTANT NATURE OF SUDAN CLIMATE

Geological succession.—According to Andrew the uniformity and thickness and type of the Nile Valley silts now being deposited shows that the Nile régime has remained constant probably throughout the Neolithic to the present day and from this we may infer a regional constancy of climate.

Fossil record.—According to Tothill, the soils of the Hashaba, Fatisa,

and Dueim pump schemes were deposited under water because fossil remains of aquatic molluscs are of general occurrence throughout the upper 10 feet of soil. The rarity of fossil remains of the land snail, *Limicolaria*, shows that since the drying out of this area the climate has never been wet enough to enable this snail to flourish and therefore that no wide fluctuations of climate have occurred in this area in recent times.

Recorded history and preservation.—The history of the Northern Sudan as known from archaeological research covers a period of 5,000 years and there is nothing in the distribution or condition of buildings erected throughout this period or of graves to suggest that the climate was essentially different from that of to-day. The perfect state of preservation of the elaborate mural decorations in the Temple of Abu Simbel just north of Wadi Halfa bears witness to anyone who has lived in the wet tropics, where all trace of decorative art vanishes so quickly, that the climate of Wadi Halfa has been as dry as it is to-day since the close of the reign of Rameses II in 1225 B.C. The fact that the flesh on bodies buried about 4,000 years ago near Kerma and excavated by Reisner was so well-preserved as to enable sex determinations to be made from it also indicates no change in basic climate.

River volumes.—Since about 1900 the Egyptian Irrigation Department has kept a record of the volume of water flowing in the main tributaries of the Nile. This record shows minor fluctuations that marched with sunspot maxima for two successive 10 to 11-year cycles and that have shown little relation to sunspots in recent years. So far as this short record goes, it shows no change of basic climate in Recent times.

FINAL MAJOR WET PERIOD IN SUDAN

There is abundant evidence in the Sudan to show that the climate preceding that of to-day was very much wetter. The story becomes clear by reference to three principal sources of information, namely, the geological succession of soils, the fossil record of these soils and the fossil record in Neolithic occupation sites.

The geological succession.—Older than, and next in succession to, the Recent silts of the type now being deposited in valleys such as the Nile and the Gash and Baraka deltas are two contrasting types of soil.

On the plains there is a thick deposit of a heavy dark clay.* In northern Kordofan and the lower parts of Darfur there is a large spread of sand in the form of fixed or non-mobile dunes, the "Kordofan sands" (goz).

The clays of the plain and the Kordofan sands were probably deposited within the Neolithic period. The goz represents an arid phase, regarded by Edmonds as preceding the deposition of the clays. On the very probable assumption that the sub-fossil shells and the Neolithic implements scattered over a wide area of the Libyan desert are of the same age, they demonstrate a higher precipitation during this Neolithic stage. It is estimated that it would correspond with a minimum northerly shift of the present 200 mm.

* This deposit has for many years been inappropriately called "Cotton Soil."

isohyet of about 550 km. to near the present frontier of the Sudan. If it is further assumed that the clays of the Gezira plain are of the same age, the observed occurrences of sub-fossil mollusc shells compared with the present day distribution of living animals would be explained as due to the same shift.

The sequence of events (arid phase—Kordofan sands ; humid phase—Neolithic clays of plain ; present-day climate intermediate between these two) is not yet satisfactorily supported by indisputable evidence of age of these deposits. It is clear, however, that the climate of the historic period up to to-day is wetter than that of the goz period, and a little more arid than that of the period of Neolithic man in the Libyan desert. Both are very minor oscillations compared with pre-Neolithic changes, and both are oscillations of greater magnitude than occurred within the historic period.

The fossil record

(a) In the Libyan desert Sandford and W. K. Arkell have shown that there is a wide distribution of Neolithic implements and of fossils of semi-aquatic terrestrial molluscs and that this presupposes a climate that was altogether wetter than that of to-day. The Neolithic climate of the Northern Sudan was, therefore, basically wetter than now.

(b) *At Erkowit.*—A residual dark clay deposit 20 feet thick in Khor Harasab contains marine cowrie shells used as ornaments, a Neolithic type of pottery and obsidian flakes and large numbers of semi-fossil shells. The shells have been collected and studied by Tothill, who says : “ Three species of pond snails that live upon aquatic plants are common (*Bullinus truncatus*, *Planorbis* and *Limnaea*) and there are a fair number of specimens of *Melanoides tuberculatus* that lives only in permanent fresh water. There are land snails of a Mediterranean genus (*Xerophylla*) and of a species now abundant at 6,000-7,000 feet in Abyssinia (*Cerastus abyssinica*). The pond snails, land snail and *Cerastus* are now no longer common in the area. Their former presence in abundance shows that the environment was wet enough to support a forest cover with water meadows and ponds and for the building by deposition, in quiet water, of clays during the Neolithic stage.”

(c) *At Shendi.*—At the northern end of the forage farm there is a site with Neolithic pottery and semi-fossil shells of the semi-aquatic species (*Ampullaria wernei* and *Lanistes carinatus*) in alluvial gravel sands, and silt at about 24 to 40 feet above the level of the irrigation canal. These may be regarded as deposits of a former abundant flow of a stream from the hills in Neolithic times and indicate that the climate was substantially wetter than it is to-day.

(d) *At Khartoum.*—Near Khartoum are many Neolithic occupation sites which have not yet been excavated. On the surface are many semi-fossil shells of the land snail, *Limicolaria caillaudi*, which has not, according to Tothill, been observed living as far north as Wad Medani and which is uncommon at Sennar, and only becomes common south of the 500 mm. isohyet. The existence of these fossils presupposes a Neolithic climate substantially wetter than the Khartoum climate of to-day.

(e) *In the Gezira.*—The upper 6 feet of the Gezira plain above the 382 metre level is probably an alluvial clay plain deposited in Neolithic

times. The soil contains large numbers of semi-fossil shells that have been studied by Tothill, who says that "the regular vertical distribution at all levels of the semi-aquatic snails (*Ampullaria wernei* and *Lanistes carinatus*) almost as far north as Khartoum shows that the climate at the time of deposition was wet enough to enable these species to survive the dry season as it does to-day in the latitude of Malakal. Towards the end of the Neolithic wet period when the Blue Nile no longer inundated the plain, it became covered as far north as Khartoum with a dense population of the land snail, *Limicolaria caillaudi*, which could only have happened with a climate as wet as that of the modern Gedaref. In the climate of to-day this land snail is abundant on the clay plains of Gedaref, becomes uncommon at Sennar and is extremely rare north of Wad Medani."

MAN-MADE DESICCATION AND EROSION

The writers of the Sudan Report therefore conclude that the evidence is very strong to indicate that the climate of to-day with its normal variation has undergone no basic change for better or worse since the close of the final major wet phase of Pleistocene times in which a Neolithic civilization flourished, at least in the Central and Northern Sudan. The soil deterioration which has occurred and which is still occurring may therefore safely be attributed to the work of mankind and to his domesticated animals rather than to any change in basic climate, and the problem of control resolves itself into bringing about changes in the ways of Sudanese peoples sufficient to restore the damage done and to prevent further deterioration of soils and rural water supplies. This objective is one that has a reasonable chance of being achieved by making careful long-term plans and by remorselessly carrying them out step by step over an indefinitely long term of years.

The recommendations of the Soil Conservation Committee deal with the application of measures adapted to the needs of the Provinces, in which the various factors, such as over-cultivation, over-grazing, incorrect burning, and excessive cutting of *Acacia* and other scrub for fuel all operate in varying degrees and combinations to denude the vegetation and reduce its capacity to protect the soil and assist in the conservation of moisture.

CONSERVATION PROJECTS

The list of recommended projects is classified in two priority categories, A and B. Priority A includes items directly concerned with maintaining the agricultural soils of the Sudan in good heart in perpetuity, with protecting the sources of the rural water supply, and with rural development schemes. The following list gives an indication of the scope of some only of the proposed projects, selected with special reference to the general matter of this Bulletin.

<i>Name of project</i>	<i>Remarks</i>
NORTHERN PROVINCE	
Atbara town perimeter.	Provision of a dairy farm is a main feature of scheme and is reproductive.
KASSALA PROVINCE	
Control of dune formation on Tokar delta.	Serious and rapid deterioration of agricultural land is occurring. General planting of adlib over delta by A. and F. Dept. approved. Also A. and F. Dept. studies of other vegetation that might be used and of devices to spread dunes by use of wind.
In Red Sea Hills.	Work now being carried out is approved in principle. Control should be transferred to Soil Conservation Board when established.
Port Sudan wood fuel supply.	A patch to be fenced off each of these jebels and fire protected and vegetation census to be made once a year to find out effect of keeping fires and animals out of jebels. Observations required over 15-year period.
	Experiment by A. and F. Dept. to terrace a strip of catchment area and to plant half the terraces to Acacia. Object is to find out if flow of water to Port Sudan underground reservoir at pipe line heads could be evened out by terracing the catchment area.
	Wood fuel supply of Port Sudan is difficult and perhaps coal and oil is the answer. Two projects recommended (a) plant up near town on coastal plain appreciable area of mesquite, (b) plant a few feddans of the outwash fan of Khor Arbaat to seaward of pipe line heads with mesquite to test possibility of utilizing waters now going to waste.
KHARTOUM PROVINCE	
Khartoum North Fodder Farm.	The town perimeter is out of control and grazing of sheep and goats essential for milk supplies for poorer people must be prohibited. To do this it is necessary first to provide alternative but controlled grazing paddocks by installation of small pump scheme just eastward of railway. Fee nil licences to graze would be given to poorest to enable the farm to pay its way.
Omdurman Fodder Farm.	The town perimeter is out of control and grazing in it must be prohibited. A forage farm is required to provide alternative grazing and dry fodder. This can best be done on the flats above the bridge. A low lift pumping scheme is recommended for production of (a) grazing at low Nile and (b) dry fodder for flood conditions. The farm should be planned to pay its way by sales of grazing and of dry fodder to those able to pay.
Khor Abu Anga Scheme.	An experiment to test possibility of spreading flood waters to enable grazing paddocks to be provided.
Omdurman perimeter.	The Omdurman town perimeter is out of control and probably best remedy is to close entire perimeter to grazing. It is proposed to test the matter by fencing in a segment including the Jebel Merkhayat catchment area.
Soba pump scheme.	Khartoum perimeter is out of control and haboob conditions prevail. Remedy recommended is to instal a pump scheme based near Soba with canals to White Nile and to Khartoum

<i>Name of project</i>	<i>Remarks</i>
Wood fuel supply for the Three Towns, 10,000 feddans sunt forest.	and to provide belts of forest and of crops. A forage farm would be maintained on a fee paying basis for those able to pay, for goats, sheep and donkeys now resident in Khartoum and its deims. This scheme would also be designed to provide water for gardens, street trees and parks and for water-borne sewage for Khartoum. It would be proceeded with as soon as a full plan has been agreed to by the Municipal Authority and approved by Financial Secretary. In order to bring the town perimeter of Khartoum, Khartoum North and Omdurman under control it is necessary to maintain the embargo on the cutting of wood for fuel in the Province. Cheap supplies of wood for fuel in the towns are essential and provision from Suki by rail is expensive. A 10,000 feddan sunt forest is required on White Nile flats up-stream of the Bridge. Should be fully reproductive.
Development of Harig areas.	BLUE NILE PROVINCE The work now being done by A. and F. Dept. in collaboration with Governor is approved in principle. The pace of development of these lands should be accelerated by provision of permanent fire lines and better water supplies.
Permanent fire line from Q.E.N. through Doka at Atbara river.	A basic grid system of fire lines is needed to protect harig and gum areas. This line would be part of the grid protecting great areas of the clay plain dura and simsim lands of Kassala and Blue Nile Provinces.
Fire protection in river-ain part of the Fung.	Annual fires do considerable damage in this area and accelerate the pace of soil erosion. The intention is that the Local Government Authority would provide and maintain wide fire breaks along the roads and also along the east-west roads from village to Meshra.
Berdab reclamation scheme.	KORDOFAN PROVINCE Active soil erosion and gully formation is occurring in this valuable agricultural area. It is proposed to use this as a centre for soil reclamation by strip planting and by contour bunding.
Kinderma Scheme.	Parts of the Nuba Mountains seem to lend themselves to comprehensive schemes involving protection of the catchment area, the construction of a small dam for securing additional water supplies, the settlement of new land on the clay plain, the draining of waterlogged areas, the preservation of the whole area by contour bunding and strip planting. Kinderma appears to be an appropriate area and should be examined in detail by the Soil Conservation Officer as soon as appointed.
Protection of a representative jebel that serves as important catchment area.	Annual fires run through the Nuba Mountains and reduce their value as catchment areas by increasing the run-off. A substantial experiment is required to find out the cheapest and, from a long-term view, the best method of establishing and maintaining fire breaks under Nuba conditions. Various sorts of earth banks and bands of various sorts of vegetation need to be fully tested.
Rural water supplies survey in Nuba Mountains.	Water supplies in parts of the agricultural lands of the Nuba Mountains have begun to fail. A survey is required of the actual wells and other supplies and of the catchment areas

Name of project	Remarks
Annual review of soil deterioration problem.	with a view to taking whatever steps may be required to safeguard and where necessary to improve supplies. Soil deterioration is active in agricultural part of Nuba Mountains and the situation requires watching. An annual report should be made by S.I.A. so as to call attention of Conservation Board to new areas requiring attention.
El Obeid town periphery control.	The area between the built-up area and municipal boundary is badly out of control and measures recommended by the <i>ad hoc</i> Committee under Chairmanship of the Governor and later agreed to by the Municipal Council should be adopted.
Periphery control of other towns and large villages.	Peripheral areas are for the most part in bad condition due to overworking, overgrazing and to cutting of firewood. First step suggested is Governor with technical advisers be asked to draw up a plan for each community for approval by the Conservation Board.
DARFUR PROVINCE	
Perimeter control of towns.	The perimeters of the larger towns all need attention and the first requisite is a carefully considered plan for each town. The Governor with technical advisers should be asked to draw up a plan for each place for approval by Conservation Board.
UPPER NILE PROVINCE	
Small scale trial of planned management in Dinka, Nuer and Shilluk tribal areas.	Serious soil deterioration due to overworking and overgrazing has taken place in the village cultivable lands of the Province and food production has become inadequate. Plan for each trial to be worked out by Governor and local staff with such assistance from Soil Conservation Board as may be required.
Introduction of a cattle improvement service.	Undue increase of cattle is a potent contributory cause of soil deterioration and is a difficult problem. The line of attack proposed consists of attempting to hold cattle population to the present level, by improving it in quality by offering a free cattle health service in return for the poorest males culled out annually to the number required to keep the adults level.
Rural water supply survey.	Planned management required to safeguard the agricultural and grazing lands of U.N.P. can be done only when water supplies have been provided. The first step is a survey to decide what sort of supplies should be provided.
Encouragement of harig farming.	U.N.P. has difficulty usually in providing its own food supply. The harig method of farming is practised but could be extended by annual survey of areas, provision of fire lines and by provision of temporary water supplies near protected blocks.
EQUATORIA PROVINCE	
Fire control by early burning.	A contributory factor of soil erosion in the Nile Congo divide area is the destruction of regenerating forest by the hot type of annual fire. In all areas where complete protection cannot yet be provided early burning should be encouraged so as to reduce the intensity of the fires.
Experiment with grid system of fire protection Yei to Yambio area.	North running streams form natural fire breaks. If east-west fire breaks could be established along existing roads we should have the foundation for a grid system of fire protection for an agriculturally valuable part of the Province. The experiment would be a full-scale test of possibilities.

<i>Name of project</i>	<i>Remarks</i>
Survey and reservation of heads of catchment areas of main streams.	These areas are the basis of prosperity of Equatoria. Agriculture is already creeping into them. These areas should be permanently preserved as forest reserves. Delimiting, marking and establishment of fire lines all required.
Experiments to ascertain best type of fire breaks.	Little is known about the possibility of using belts of vegetation varied to suit climatic belts, as fire breaks. Certain trees, bushes and herbage plants all have possibilities. The matter should be put to serious test because the cost of maintaining hundreds of miles of fire breaks will be substantial unless a permanent type can be evolved. One substantial isolated hill to be included.
Reservation of Imatongs.	These mountains are the most important catchment area east of the Nile. Run-off is being increased by agriculture creeping in and by annual fires. The process that has been in hand since 1941 of creating the area a Forest Reserve requires acceleration.
General introduction of contour strip farming.	Because the soils of Yei, Maridi and Yambio erode so easily, it is important to introduce the habit of making a contour strip between cultivations throughout this area. At a later stage earth bunding can be added where it proves to be necessary.
Government demonstration of soil conservation.	All farms and experimental plots controlled by the Agricultural Dept. are now completely protected with bunds. These excellent demonstrations should now be extended to include government and mission controlled gardens and the precincts of centres of administration. Erosion caused by government roads should also be dealt with at this stage.
New agricultural projects in Yei to Yambio area.	It is understood that new agricultural projects are likely to come into being on a planned basis in the Yei Yambio area. It is assumed that the lands will first be fitted with whatever soil conservation devices are considered to be necessary by the Soil Conservation Board.
Irrigation experiment.	Rains are somewhat erratic even in the Yei to Yambio area, and crops sometimes suffer. No information is available as to whether essential crops could be secured by occasional use of gravity water from semi-permanent streams. A pilot scheme is required to test possibilities.
Improvement of the hafir.	The hafir must remain as a source of water. It is necessary to evolve a type that will provide uncontaminated water and full-scale experiments are required.

FOREST RESERVATION IN THE GOLD COAST

A. FOGGIE

With an agricultural foreword by

J. H. HINDS

FOREWORD

1879, 1896 and 1901 are fateful dates in the recent history of the vegetation of the Gold Coast for they mark respectively the introduction of cocoa by Tettie Kwashie, the commencement of railway construction, and the extension of British rule to cover the present Northern Territories.

The three events, though affecting different parts and people of the Gold Coast, had this in common, that they not merely displaced but destroyed the equilibrium previously existing between man and the vegetation of his environment in the Gold Coast. Increasing inroads were made and still continue to be made not only into the area occupied by natural vegetation but upon the resources of the soil which once supported that vegetation with no loss of fertility.

The new factors operated as follows :—

- (a) *Cocoa* : This crop proved exceedingly successful, and the area under it was rapidly increased (exports rose from 80 lb. in 1891 to 260,000 tons in 1948), and large tracts of forest were cleared in the process.
- (b) *Railways* : The introduction of railways not only accelerated the development of cocoa farming, but stimulated the extraction of valuable timber (5,700,000 cubic feet, mostly hardwood, were exported in 1947) and also brought into being centres of dense population in mining areas and elsewhere with special problems of their own as regards food and farming.
- (c) *Northern Territories Protectorate* : British rule brought about the cessation of slave-raids into this area, and provided roads, schools and hospitals. Static populations arose around these amenities, increasing in number as epidemic diseases such as smallpox and cerebrospinal-meningitis were brought under control, but exerting an ever-increasing pressure on the soil. This was accentuated by the fact that, for the first time, crops such as groundnuts, yams and grain could be

exported to the South, using the roads (and motor transport which later appeared on the scene). The cattle population also rose rapidly following upon rinderpest control.

Farmers in all parts continued to rely on shifting cultivation as the basis of their farming, although many of them could no longer fallow the land for sufficiently long periods ; soil fertility has consequently declined over large areas in both the North and South of the country. Soil erosion is serious in the Northern Territories. The policy of the Department of Agriculture is to devise and demonstrate to the farmers methods of land use which are not merely exploitive as at present. Considerable success has been achieved in the north-east, and to a less extent in the north-west of the Protectorate in establishing mixed farmers who use farmyard manure to fertilize the land and who practise contour ploughing to conserve the soil. Other measures successfully introduced into the Northern Territories are the control of grass-burning over large areas as the prime anti-erosion measure, and controlled dry season swamp grazing in the more heavily populated regions. Planned land use is being studied in co-operation with other Departments, and work commenced in 1948 on a pilot area covering 12 square miles at Dedoro-Tankara in the Northern Territories ; this scheme involves the construction of terraces through the area for soil and water conservation.

The problems of the South are perhaps not so urgent as those of the North but are equally profound, especially with regard to the problem of maintaining soil fertility. An extensive series of detailed experiments scattered throughout the Gold Coast was initiated in 1948 to study crop response to artificial manures, mulch and farmyard manure, and should in due course throw a good deal of light on this major problem.

A new Division of the Department of Agriculture has been created to carry out a soil survey, primarily of the forest areas of the Gold Coast. It has already done valuable work in selecting areas suitable for mechanized agricultural projects, and has accumulated a fair body of knowledge concerning cocoa soils and the rooting systems of the more important trees and crops. The work of the detailed reconnaissance soil survey of the Gold Coast commenced early in 1949 ; the vegetation, topography and possible land use of the areas traversed are recorded contemporaneously with the soils encountered. A complete stock-taking of the vegetation and soil assets of the country is thus being compiled. The survey is being carried out not for its own sake, however, but in order that the best possible use can be made of the country's resources.

Summing up, man as a biotic factor in the Gold Coast has assumed greatly enhanced importance within comparatively recent years. How and at what level he will again come to terms with the soil and vegetation of his environment is a matter for speculation. It is obvious that methods must be devised to enable man to live not, as it were, parasitically on the land and vegetation, taking all and giving nothing, but that he should live in symbiosis with them, conserving and replenishing all that is good and useful. If this cannot be achieved there must inevitably be a gradual but progressive deterioration of the soil and vegetation assets of the country.

FOREST RESERVATION IN THE GOLD COAST *

THE Gold Coast is a territory with a sea front on the Gulf of Guinea of 260 miles from 1° East to 3° West Longitude and extending inland for 400 miles from 5° to 11° North Latitude. It has a total land area of 91,843 square miles and a population according to the 1948 census of 4,095,000 of whom 4,088,000 are indigenous. The land is generally of low relief, rarely exceeding 2,000 ft. There is, however, a very important watershed generally known as the Scarp which runs from north-west to south-east till it reaches the valley of the Volta River near its outflow to the sea. All land to the north-east of it drains to the Volta while south-west of it drains to the sea.

Politically, the country is divided into four, the Gold Coast Colony proper, Ashanti, the Protectorate of the Northern Territories, and British Mandated Togoland.

When considering the existing allocation of land as between agriculture, grazing and forestry in the Gold Coast, it is essential to remember that the British Colonial Government has not at any time, and does not now lay any claims to the ownership of land in any part of the area. Except for certain small areas which have been taken over or purchased by Government for specific purposes such as European townships, railway land, land for waterworks and one Forest Reserve of 50 square miles, the ownership of all land is vested in the indigenous population, mainly in customary ownership under native law. In the Northern Territories the land is considered by the indigenes as part of their religious beliefs to have an entity of its own and is not owned but held by the people under religious practices. This is recognized by the Government.

There is in the Gold Coast therefore no such thing as definite allocation of land as between agriculture and grazing; only since 1927 have powers been taken under the Forest Ordinance to allocate land to forestry. Here again this does not alter the ultimate ownership of the land which remains vested in the tribe occupying it or in native purchasers of such land. The powers of these owners are restricted in reserved forest land in that it cannot be put to use other than the growing of a forest tree crop; its management as such is largely in the hands of the Colonial Government Forest Department, but the profits of such use accrue to the ultimate land owner.

When this is borne in mind, it will be seen that, as reservation of forest land only commenced on an extensive scale in 1927, the existing distribution of forest, agriculture and grazing on the land is the result of economic and bionomic forces on the indigenous population working within the physiographic framework of conditions and is not the result of any planned or directed effort by the British Colonial Government.

As such, any analysis of the present conditions can only be of value when considered in relation to ecological regions and in this respect the Gold Coast can be divided into four such regions (see map).

* Paper presented to the *Conférence Africaine des Sols*, held at Goma in the Belgian Congo on November 8 to 15, 1948.



They are :

Closed Forest Zone, the " Zone de la forêt dense " of M. Aubréville ;

South-eastern Savannah Zone, a triangle stretching from Winneba to the frontier of French Togoland and extending northwards into British Togoland ;

Savannah Forest Zone, covering the greater part of the Northern Territories, north Ashanti, northern Togoland and extending down the Afram River in the Colony as far as its confluence with the Volta ; and

North-eastern Savannah Woodland Zone in the north-eastern corner of the country ; this is also a savannah woodland or forest zone but requires separate consideration.

The Savannah Forest Zone is M. Aubréville's " Zone des savanes boisées guinéennes," including the vegetation of his " District préforestier " and " District de la Guinée française." The North-eastern Savannah Woodland Zone has considerable affinity with his " Zone des savanes boisées soudanaises " ; climatically, it does not fall within the limits he gives, however, and it is probably an extension southwards of his zone effected by extreme density of population.

CLOSED FOREST ZONE

This covers the south-western corner of the Gold Coast extending up the western frontier with the French Ivory Coast as far as latitude $7^{\circ}45'$ North. The approximate present boundary of the zone runs east and then south-east down the valley of the Afram till it reaches the Volta ; it is generally beyond the watershed of the Scarp. Beyond the Volta there is an outlier of this zone over the Togoland hills. To the south-east lies a savannah zone. Between the closed forest zone and this, the boundary is very indefinite and subject to intensive interference by cultivation, but may be taken at present to run down from Ho through Akuse to the coast west of Winneba.

The climate of this zone may be defined as having an annual rainfall generally exceeding 1,350 mm. (53 in.) but occasionally as low as 1,270 mm. (50 in.) distributed in two peaks, generally June and October, but with considerable variation from year to year. The dry season is generally only of 3 months' duration with a monthly rainfall in occasional storms of 25 to 50 mm. (1-2 in.). The relative humidity at 9 a.m. is high throughout the year at 80 per cent.

The natural climax vegetation of this zone is the Tropical Closed Forest with edaphic variations. Few areas of entirely virgin forest remain, however. Throughout the centuries the indigenous peoples have farmed through it with their shifting cultivation ; although in the past with very long fallows, the forest returned to practically its original state, on the margins there have been encroachments by the savannah forest following fire. With the increase of population following British occupation, the

cessation of tribal wars and slave raiding, the development of mining trade and the introduction of cocoa cultivation, there have been great alterations to the vegetation and considerable areas are now under crops. These are either plantation crops such as cocoa, oil palm, kola or citrus, or annual or biennial food crops. Considerable areas are under fallows so short that they do not develop beyond a dense bush stage. Where land is under fallow long enough for a true forest structure to be formed, it is classed as forest.

The area of this zone was on the latest (1947) estimate of the Forest Department placed at 30,385 square miles of which 16,900 square miles (56 per cent) were still under forest. The population within this zone on the 1948 census is estimated to be 2,250,000.

Cocoa, kola and citrus production is wholly confined to this zone and the major oil palm production also falls within it. The staple food crops are plantains and cocoyams (*Xanthosoma sagittifolium*) with maize and cassava as secondary crops. The true yam (*Dioscorea* sp.) is also grown but not quite in the quantity of the others. Rice is also grown and its cultivation is extending.

The fact that the true yam has not been the prime staple in the Gold Coast Closed Forest Zone has had considerable effect on the vegetation. To attain a full yield of yams, complete clearance of the forest is necessary in intensive cultivation. The Gold Coast peasant has been content in the past to make a partial clearing, quite a number of trees remaining standing and alive after the clearing and burning. The maize crop is taken off immediately after clearing and the plantains and cocoyams come on later and ripen and bear under the partial shade. A certain proportion of true yams are grown with these other crops, but the whole area is not cultivated and cropped with them.

The result of this cultivation with incomplete removal of the forest was that, on abandonment of the farm, usually after 3 years, there was a very rapid return to forest; with some standards surviving and a great deal of coppice regrowth of forest tree species, the seral stages of recovery through *Alchornea*, Musanga, Macaranga or Trema bush to the forest form was comparatively rapid. This explains the very high proportion still classed as forest.

Within the last 30 years, however, there has been a gradual change. With the advent of cocoa, the peasant planted cocoa among his food crops; when it was exhausted, the area did not pass to fallow, but was cleaned and maintained as a cocoa plantation. With the increase of population and increasing urbanization in the larger towns and around mining areas the growing of food for sale rather than for purely subsistence farming has resulted in more extensive clearing and an increase in the cassava planted. The fallows have been gradually shortened and now, around the major towns and along the south-eastern edge of the zone, little forest remains and the land is now being heavily cropped for maize and cassava. It is estimated that 300 square miles per annum are being converted from forest or forest fallow to permanent agriculture or short bush fallow land in this zone.

There is no grazing in this zone as tsetse and trypanosomiasis prevent the introduction of cattle and only a few sheep and goats are maintained. It is, however, the timber-producing area of the country. All the timber exports come from this zone and all the sawn timber used elsewhere is drawn from it, the savannah forests producing only firewood and round building poles at present.

Regarding the present distribution of forest and farm within this region on a broad scale, there are a number of large population centres from which farming has spread out and the forest has been largely destroyed.

The largest of these is probably north, north-east, north-west and west of Accra extending beyond Koforidua to Tafo in the north, to Bisa in the north-east, Swedru in the west, and beyond Asamankese north-west. This is an area which was settled relatively early and where the tribes, the Krobos, Akims and Akwapims, are fairly industrious farmers. It is also the area in which cocoa was first introduced. Food and cocoa farming has been pressed on till there is very little forest left. With the increasing population and the removal of land put under cocoa from food production, the fallows have been shortened to a dangerous degree and there is a considerable movement of people from these areas to less developed areas.

Another area fairly heavily populated lies immediately west of this in the Fanti country, north of Cape Coast and Saltpond. The northward development of intensive farming here was, however, slower than further east. This area probably suffered most heavily from slaving, at first from the English trade and later from raiding by the Ashantis from the north. The country here is now being rapidly completely farmed.

Another major centre is around Kumasi which has been very rapidly opened up in the last 50 years with a great deal of cocoa planting. Intensive farming now spreads out in star-shaped fashion around Kumasi along all roads; for a radius of 8 to 10 miles round, the forest has completely gone and corn and cassava are cropped with short fallows and the cultivation of plantains is falling off.

The last main area is that around the mining area of Tarkwa. Here the demand for food and fuel, the latter both for industrial and domestic use, has resulted in the complete clearance of the forest over a wide area especially north and north-west of Tarkwa town. The land has been converted to food cropping with a fairly short fallow in which only dense low secondary bush grows up. Cocoa growing is not practised to any extent here.

Similar smaller areas occur round the long established mines at Obuasi and Bibiani, but here cocoa is also grown.

The areas where continuous large stretches of forest still occur are in the Western Province of the Colony in Axim, Dunkwa and Wiawso Districts and in South-west and South Ashanti. Here farming is still spreading out from the relatively scattered villages into either primary or very ancient secondary forest.

Over the intervening areas between these extremes of deforested and primarily forested country, the forest, cocoa farms, food farms and fallows in various stages are distributed like patchwork round the villages.

Very commonly there is a strip of forest between one village and the next and other broader strips generally occur between two tribal areas ; very often ownership is disputed over such strips.

The distribution of the cocoa farms within one village area has been very intensively studied by Beckett in his "Akokoaso : A survey of a Gold Coast village " in which he shows how the farming has spread out around the village. The farms are not continuous, however, and there are many small patches of forest left between farms on areas unsuitable for cocoa, and forest fallows of considerable age occur. These, with the trees remaining within the farms, give the country a generally forested appearance, except in the very heavily farmed areas mentioned above. As the population increases, however, and the areas now being opened for food and cocoa pass over to cocoa, all the remaining forest will pass to food farming. At the present time, however, a very large proportion of the timber exports of the Colony and practically all the local requirements of fuel, poles, pitsawn timber and minor forest produce are drawn from such areas.

Soil erosion in this zone is not acute and appears only locally round towns and villages. Very little erosion occurs in the cocoa plantations as bush vegetation rapidly returns on abandoned farms. Soil deterioration is, however, a very serious problem and one which will become ever more pressing as the population increases. No method of permanent food farming has yet been discovered for this zone, and as the forest fallow becomes a bush fallow and is continually shortened the rate of deterioration increases.

FOREST RESERVATION WITHIN THE CLOSED FOREST ZONE

An early attempt in 1911 to introduce a Forest Ordinance met with such determined opposition on the part of the local inhabitants that it was withdrawn pending enquiry. This had not been completed before the 1914-18 War which put a stop to it and also led to the closing of the Forest Department. Earlier, however, the Government had purchased outright 50 square miles of forest land lying between the Anum and Prah Rivers in South Ashanti. This was in dispute between Ashanti and the Akims ; to ensure the Ashanti frontier followed the Prah River, the Government bought up the disputed area which was later constituted a Forest Reserve.

In 1919 the Forest Department was revived, and from 1919-1927 a policy of persuasion was followed by trying to induce the local native authorities to place areas under reservation by their own laws. Only 240 square miles were, however, reserved in this way, and in 1927 a Forest Ordinance was passed through the Legislative Council giving the Colonial Government powers to enforce reservation where necessary. Power to create the necessary reserves under their own by-laws was left to the local native authorities, but if they failed to do so or if they failed to administer their reserves competently, the Colonial Government could create the necessary reserves under the Ordinance. From then on reservation proceeded rapidly. The authority given in the Forest Ordinance for reservation is :

"Lands in respect of which the Governor in Council is, on the advice of the Conservator of Forests (now Chief Conservator of Forests), satisfied that the forests thereon ought in the public interest to be protected from injury or destruction, or from any further injury or destruction, as the case may be, in order

- (a) to safeguard the water supply of the District ; or
- (b) to assist the well-being of the forest and agricultural crops grown on the said lands or in the vicinity thereof ; or
- (c) to secure the supply of forest produce to the inhabitants of villages situated in the said lands or in the vicinity thereof."

Reservation was therefore for general protective purposes and the maintenance of future local supplies. Reservation for the purpose of maintenance of the export market was not included.

From 1927 to 1935 reservation was mainly devoted to the major hill masses and watersheds within the closed forest zone, the Forest Department staff and work being concentrated in this zone. This was fairly successful as these hill masses were not heavily populated and in many cases lay between main tribes or divisions of tribes. Areas where development had proceeded too far were, however, the Akropong ridge, the hills just north of Accra, sections of the Southern Scarp, and the scarp at Mampong.

In 1935 the then Conservator of Forests, Capt. R. C. Marshall, submitted a confidential "Report on the Gold Coast Forest Problem" in which the aims for further reservation were laid down in more detail. This listed reserves for water conservation, on headwaters ; barrier reserves along the present junction between the Savannah Forest and Closed Forest on the north, north-east and east ; shelterbelt reserves, strips of forest a mile or more wide crossing the country at intervals as far as possible in a south-east to north-west or east to west direction ; and timber and fuel reserves to meet local scarcities. The barrier reserves were to ensure fire protection and prevent the further extension of the savannah forest to the South and West. The shelterbelt reserves were to ensure a reasonable distribution of forest over the country assuming that the present patches of forest between farms, and standards in farms, will eventually disappear. It is hoped that the reserved shelterbelts will maintain present climatic conditions especially regarding relative humidity which is important for the well-being of the cocoa.

Since 1936 this policy has been followed as far as conditions permit. Capt. Marshall suggested an ideal figure of 8,800 square miles of reserved forest in and around the Closed Forest Zone, including barrier reserves in the ecotone between the climatic Savannah Forest Zone and the Closed Forest Zone but suggested the actual attainable would be in the region of 7,000 square miles. In 1947, 6,454 square miles had been reserved, 5,894 square miles actually within the zone and 560 square miles in the ecotone, that is, 19.4 per cent of the Closed Forest Zone. Reservation is still proceeding and adjustments of some of the earlier reserves are

contemplated. The complete soil survey of the zone which is planned will enable future cocoa planting to be better directed ; when this is completed there may be further reservation and adjustment.

As mentioned the local and export demands for timber, fuel and minor forest products are at present met from outside the reserves. The present reserved area is sufficient to meet all future local demands when these supplies are exhausted and to allow some surplus for export.

The activities of the Forest Department are in the main directed to the reserved forest estate ; only a relatively loose control is exercised over the unreserved forest through the operation of the Timber Protection Ordinance, which sets minimum girth limits for the felling of certain major economic trees, and the Concessions Ordinance, under which the Chief Conservator of Forests can impose restrictions, limitations and directions on timber concessionaires with a view to ensuring full and regular exploitation of the timber resources outside the reserves. These do not, however, affect the peasant economy. The villages draw their requirements from the unreserved forest at will, and as yet only in certain localities need to draw on reserves. All reserves except a few specially created game sanctuaries are open for hunting, fishing and snail gathering.

Where in the course of reservation local communities are unduly cramped for land they are permitted to take up food farming on the taungya system, but only very small areas are so far involved.

SOUTH-EASTERN SAVANNAH REGION

As already mentioned this is an area roughly triangular in shape stretching from a little beyond Winneba on the west to the frontier of French Togoland on the east and extending northwards into British Togoland. It abuts on the Closed Forest Zone to the north-west and north. Whether it is properly one ecological region is in doubt. In the north and west, large areas may originally have lain within the Closed Forest Zone but through biotic interference all resemblance to this zone has been lost. The dominant vegetation is grass, sometimes with occasional trees, sometimes approaching savannah woodland. There are occasional areas where grass is replaced by maquis and others which are pure palm groves. Climatically this area has a rainfall ranging from 750 mm. to 1,250 mm. (approximately 28 in. to 50 in.) with the main rains in April, May and June and second rains in October and November. The main dry season is December to February with a second dry season in August and September but 25.4 mm. (1 in.) of rain may occur every month mainly in storms. The 9 a.m. relative humidity is high and even throughout the year, averaging 79.6 per cent. In the small total precipitation it differs from the Closed Forest Zone but the distribution and relative humidity are quite different from the Savannah Forest regions to the north and east of the Closed Forest Zone. The area of this region is 3,600 square miles and it bears a very heavy population of 590,000 persons. This is not evenly distributed, however, 135,000 occurring in Accra town while the Shai plains east of Accra are very lightly populated.

The whole of this region is deforested. Coconuts are grown extensively

along the coast and oil palms are cultivated in quantity inland. Cattle are reared on the Shai plains and maize, cassava and yams are generally cropped, while around Keta intensive agriculture is practised, onions especially being grown. It is an area seriously short of fuel which imports all its timber, with the exception of beams, for which the Ago beams, hewn trunks of the *Borassus* palm, are used.

No forest reservation has taken place in this region but to meet the demand plans are on foot for the creation of fuel plantations, it is hoped through the medium of the native authorities. In the coastal strip south of the Keta lagoon, detritus from the coconut palm plantations is all collected and used for fuel. It is believed that this constant removal of all potential humic material has gradually caused serious soil deterioration and led to a great increase in disease in the palm groves.

This region is mainly flat or gently undulating country and is not subject to acute erosion, though soil deterioration is occurring.

SAVANNAH FOREST ZONE

This lies to the north and north-east of the Closed Forest and at present is estimated to cover an area of 543,000 square miles. The rainfall in this zone varies between 1,000 mm. (under 40 in.) to 1,400 mm. (55 in.). There is a pronounced dry season of 4 to 6 months and the 9 a.m. relative humidity shows considerable variation, falling to 40 per cent in January and rising to 80 per cent in August. In the southern parts, the rainfall distribution still shows two peaks, but north of 8° 30' latitude there is only a single rainy season with the heaviest fall occurring in August.

Around the edge of the present Closed Forest Zone there is a wide area in which the savannah forest is believed to be biotically induced by clearing for farming and subsequent annual bush fires, and where, if this were stopped, the closed tropical forest would return on all the better soils. It is, however, very hard to draw a line between this and the true savannah zone immediately to the north, Aubréville's "District préforestier," in which savannah forest covers most of the area but where there are islands of closed forest on better sites. If freed from annual burning, the wooded savannah would here probably develop into a light closed deciduous forest but would not develop into the closed tropical forest. North of this again is Aubréville's "District continental de la haute Côte d'Ivoire et du haut Togo" which is continuous across the northern part of the Gold Coast. It is probably true climatic savannah woodland.

The whole of this savannah forest zone is very lightly populated. It is estimated from the figures of the 1948 census that only 798,000 occupy the 54,300 square miles (14 to 15 persons per square mile). Large areas are still practically uninhabited, especially in eastern Ashanti-Akim, the Afram plains and the southern part of the Northern Territories.

The crops grown are the true yam, maize, groundnuts and bambarra nuts in the south and groundnuts, millet, guinea corn and bambarra nuts in the north. Shea butter (*Butyrospermum parkii*) grows in the north. Cattle are kept in the extreme north-west of Ashanti and in the Northern Territories generally, but the cattle population is not high.

Shifting cultivation is practised, but with the low population density a long fallow is still common. Erosion occurs wherever there is a local concentration of population; as population increases, steps will have to be taken regarding it, but it is not yet a major problem in this region.

On a rough estimate, 80 per cent of this area is still under savannah forest including long fallows, the balance being under semi-permanent cultivation or reduced to grass. Very little reservation has yet been done in this area, except around the Closed Forest Zone where 560 square miles have been taken up, mainly in the savannah which is believed to have been biotically induced, and 200 square miles along the southern boundary of the north-eastern region.

This is not due to lack of interest in this region but to lack of staff. As the forestry problems in this area were not acute, the policy has been to concentrate first on the Closed Forest Zone, then on the extreme north-eastern region; eventually it is hoped to cover this Savannah Forest Zone with a reasonable distribution of reserved forest areas. The two proposed pilot mechanized groundnut growing schemes are both situated in this region, and reservation will be planned in association with them.

NORTH-EASTERN SAVANNAH WOODLAND REGION

This is bounded on the west by the Sissili River, on the south by the Volta, and east and north by the colony frontiers. It covers three sub-districts, Navrongo, Kusasi and Frafra, with an area of 3,559 square miles and a population of 455,000 (an average of 128 persons per square mile).

The rainfall is 1,000 to 1,100 mm. (under 40 to just over 44 in.) per annum, falling from May to October with an extreme dry season of 6 months when the relative humidity may fall to very low levels.

These are just above the limits given by Aubréville for his "Zone de savanes boisées soudanaises," but with the heavy population following cultivation, the vegetation of this region is now more closely allied to the Soudanese Zone than the Guinea Zone, *Acacia* and *Combretum* spp. being dominant.

The type of farming is permanent and semi-permanent, the population living in isolated compounds on their farms. The land near the compound is manured and in permanent cultivation. The further fields are cultivated with a short fallow in the rotation. In the farming areas, the population density may rise to 500 and even 600 per square mile. The present distribution of the cultivated land presents a major problem as it is now on the low ridges and watersheds. The major river valleys are not now generally cultivated and are under secondary savannah regrowth. It is believed that they were at one time cultivated, but with soil deterioration, erosion and ill-health due to sleeping sickness and onchocerciasis, the population has moved out and up to the watersheds. Erosion in all its varying forms is acute throughout the region. Lateritic pan formation which M. Aubréville has termed "bovalisation" is a major problem. There is a considerable local shortage of building poles and firewood, especially the former, fuel needs being largely met by the use of millet and guinea corn stalks collected

from the fields. The livestock population is high and over-grazing of available grasslands a very serious problem.

Only in 1938 was the Forest Department staff position sufficiently strong to post a senior officer permanently to this region and to commence reservation.

The unpopulated areas of savannah woodland in the major river valleys were first reserved ; about 500 square miles (14 per cent) are now under reserves or demarcated with a view to reservation. It is realized that, though their protection and proper management may ameliorate the position as regards supplies of poles and firewood, they are ineffective in general prevention of erosion and conservation of water supplies. The catchment areas which normally would be the areas for reservation are, however, the most heavily cultivated and very great transfers of population would be necessary before they could be returned to forest. Present policy is therefore to declare them land planning areas and by the joint efforts of the Administrative, Agriculture, Animal Health and Water Supply and Forest Officers to utilize the land to the best advantage. Burning will be stringently prohibited, non-arable land will be reserved for forest growth, and by improved farming methods, broad-base terracing where necessary, contour ridging, increased manuring and better cropping it is hoped to reduce erosion, conserve the water supply and prevent laterite pan formation within the arable. The grasslands would be subject to rotational grazing, and with freedom from burning it is hoped they will be improved. It may also be necessary to control the numbers of stock.

It is hoped by closure and planned exploitation and treatment of the existing savannah woodland to improve the yield sufficiently to meet local needs for poles. Extensive planting schemes are not contemplated, but small plantings will be made where necessary for town supplies.

CONCLUSION

The general position regarding Forest Reservation in the Gold Coast may be summed up as follows :—

In the Closed Forest Zone it is satisfactory, in the North-eastern Savannah Woodland Region the problem is being tackled energetically, in the general Savannah Forest Zone and the South-eastern Savannah Region little has yet been done, not through lack of need or intent but from lack of staff. They will, it is hoped, eventually bear a proper proportion of reserves and plantations to ensure protection and to meet local needs.

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